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FINANCE MINISTRY

SURVEY DEPARTMENT, EGYPT.

THE TOPOGRAPHY AND GEOLOGY OF THE PENINSULA OF SINAI

(SOUTH-EASTERN PORTION)

By

W. F. HUME, D.Sc. (London), A.R.S.M., F.G.S., etc.
Superintendent, Geological Survey.

CAIRO:
NATIONAL PRINTING DEPARTMENT,
1906.

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TOPOGRAPHY AND GEOLOGY

OF

SOUTH-EASTERN SINAI

PLATE I.

ENTRY TO WADI NASB RAVINE

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THE

TOPOGRAPHY AND GEOLOGY OF EASTERN SINAI.

I. TOPOGRAPHY.

CHAPTER I.

INTRODUCTORY.

The Peninsula of Sinai has been justly described by Captain H. S. Palmer as follows:— (Ordnance Survey of Peninsula of Sinai, Part I, Chapter 1, p. 17) "The Peninsula of Sinai, or at any rate the greater part of it, is in reality one of the most mountainous and intricate regions on the face of the earth: sand is a feature seldom met with, plains are rather the exception than the rule, the roads are often steep and rugged, and wind for the most part through a labyrinth of narrow rock-bound valleys. It is a desert, certainly, in the fullest sense of the word, but a desert of rock, gravel, and boulder, of gaunt peaks, dreary ridges, and arid valleys and plateaux, the whole forming a scene of stern desolation which fully merits its description as the 'great and terrible wilderness.' So far from there being nothing to survey, the topographer may well shrink from the task of delineating its countless 'intricacies.'" Yet here and there, where after sudden thunderstorms the storm-waters rush down the main valleys, are found some fertile spots, oases of palms, seyal trees and rushes, producing pictures full of life and beauty in the midst of the stern hills that surround them. Perennial streams run down the wadis * of Kyd, Hebran and Isla, in the latter valley forming a small waterfall whose sides are covered with maiden-hair fern; groves of tamarisk and palm fill the upper portions of Nasb gorge; while at Dahab and Nebk the latter fringe the coast-line at the points where the two great drainages of Nasb and Kyd enter the Gulf of Akaba. Nevertheless these occurrences are rare, and in many places, as near Ras Mohammed and in the schistose hills south of Dahab, unmitigated desolation holds sway.

* Wadi is the Arabic name for a valley, Jebel or Gebel for a hill.

The portion of Eastern Sinai considered in this memoir extends from Ain-el-Hudera in latitude 29° N. to the southern end of the peninsula at Ras Mohammed, the part most particularly studied and mapped in detail being the triangular area bounded on the north by the transverse range, and to the east and south by the Gulf of Akaba and the Red Sea. This isolated position behind rugged mountain-barriers traversed only by passes, themselves not especially easy, is of itself a reason why this region has been so largely neglected, while in addition, it is at a considerable distance from Suez and Tor, the only ports of the peninsula. Thus it requires a six days' journey from Suez to the Shelala Pass, which is the gate of the south-eastern triangle, the same point being reached from Tor in four days, and then only after passing over the steep and boulder-strewn col at the head of the Tarfa valley.

The early history of Eastern Sinai is wrapped in obscurity, though many writers believe that the Israelites on leaving Sinai marched to the two famous wells of Wadi-el-Ain and Ain-el-Hudera, their second station, that of Hazeroth, being somewhere in their neighbourhood. Be that as it may, the presence of numerous stone circles of very varied form and often placed in most unexpected localities, shows that man was at one time far more widely distributed in the region than he is at present, over thirty perfectly circular stone-circles being sometimes placed close together on a single gravel terrace. That these must be of very ancient date is proved by the occurrence of Nabathean (Idumean) inscriptions on some of these buildings at the foot of Abu Mesud, but there is at present no evidence in support of the suggestion made by Mr. Holland, that they may have owed their origin to the Amalekites. With these exceptions, the records are silent, no Egyptian inscriptions having been met with in Eastern Sinai, * and all traces of a Roman occupation being absent, although the peninsula was annexed to the Roman empire by Cornelius Palma, prefect of Syria. The Nabatheans were a people from the north-east, who took possession of the commercial route abandoned by the Phœnicians, and from the famous rocky city of Petra commanded the peninsula down to about the period of the birth of Christ.†

Only with the growth of the monastic principle among the early Christians in the fourth century did this wilderness again become peopled with hermits, who could in these mountain fastnesses find the solitude they sought, and who have left the traces of their presence in

* Those in Western Sinai have been frequently described and figured.

† Baedeker's Lower Egypt, 1895, 9,236.

the rectangular stone buildings, generally low-doored and roofless, which are situated in the most out-of-the-way localities.

These isolated outposts were particularly subject to the inroads of the wild tribes of these mountainous regions, the Saracens and Blemmyes having on several occasions carried out massacres on a large scale, while after the rise of the Moslem power, the mountaineers seem to have made an easy transition to the new religion, and to-day the Sinai Convent alone remains as an interesting relic of the prevalence of monasticism in the peninsula. Although the eastern mountain region thus early ceases to play any part in the historical record, the Gulf of Akaba has at many periods been the successful rival of the Gulf of Suez, being the principal waterway not only for the fleets of Solomon and Ahab, but also of great importance to the Crusaders and Saracens; Akaba, at the head of the eastern gulf, being the scene of many fierce fights before Saladin finally obtained the mastery. As Dean Stanley has given an eloquent account of these changes, in his work on "Sinai and Palestine," the reader is referred to the latter for further information. The peninsula is administered by the Intelligence Department of the Egyptian War Office, the chief government official in the peninsula being the Commandant of Sinai, who resides at Kala'at-el-Nakhl, there being also a *Nazir** at Tor, though the latter town is practically controlled by the Quarantine Board having its centre at Alexandria. The relations between the Government and the tribesmen are negociated through the head sheikhs of the peninsula, each separate tribe having also its own sheikh, who seems to be invested with considerable authority.

The inhabitants of this mountainous region have fully maintained their good reputation for honesty, readiness to oblige, and independence of character. In general they are slight in build and somewhat short in stature, but very active climbers and keen sportsmen. Even the children early learn to recognize the plants and animals with which they come in contact, and the necessity of finding water and camel-food brings them into close acquaintance with every recess of their hills. Their *dwellings* are of the simplest description, consisting of dark or striped cloth stretched on a few poles, and so placed as to be under the protection of some rocky ridge. A partition in the centre divides them into quarters, the mens' from the womens', while furniture is limited to camel-saddles, baskets for obtaining camel-fodder, water-jars and a

* A military officer with civil powers.

few other simple utensils of primitive construction. Their *food* certainly does not err on the side of luxury, parched corn, coffee, lentil soup, and unleavened bread being the staple articles, while in the season dates and the fruits of the *nebk* (about the size of a crab-apple) are added to the store. The man's *dress* is equally simple, consisting of a galabia, or white cotton robe falling a little below the knee and drawn in at the waist by a leather girdle.

The head-dress consists of a strip of white cloth loosely wound in the form of a turban, with the ends falling so as to protect the head completely from the sun, but many of the younger men wear nothing but the skull-cap which underlies the turban. A dark burnous is often thrown over the galabia, but seems to be made of very thin material, except in the case of the well-to-do members of the community. The Arabs almost invariably go barefoot, though many of them possess sandals which are worn on state occasions; their weapons are flint-lock guns, often of great length and primitive construction, swords (usually straight) and daggers or knives worn in the belt or on the arm. The palm-groves and nebk-trees belong, not to individual owners, but to groups of three or four who form a close partnership, the scarcity of water or the ripening of the dates being the chief factors in determining their movements.

Though all the Arabs of the peninsula are included under the general term of the Towara (inhabitants of Tor), they are sub-divided into a number of tribes, three of which are of more importance than the others in the eastern portion of Sinai. Of these the most numerous are the *Emzeina*, who, according to the Ordnance Survey Report, are the descendants of an illustrious Arab tribe, and have the characteristics of being darker and wilder-looking than the remaining inhabitants of the country. The other members of our expedition were mainly recruited from the *Aleiqat*, who live round Wadi Nasb, and the *Sawaliha*, who appear to be the most numerous of the three tribes above-mentioned.

Previous Geographical Exploration in Eastern Sinai.

Notwithstanding that so many travellers have visited the western side of the peninsula, it is a noticeable fact that scarcely any of them have examined the south-eastern region and still fewer have mapped any portion of the country under consideration. In 1844 J. Russeger published a map of Arabia Petrea and the southern part of Syria,

bringing together previous records so far as he had been able to obtain them, but he himself did not cross into Eastern Sinai. Nevertheless, the compilation is interesting as showing how little the detailed structure of the country had been examined, it being difficult to recognize any of the prominent valley-systems. Comparison with our map will show what fundamental differences exist between it and this compilation of the earlier efforts.

In 1868 the Rev. F. W. Holland, M.A., published a map in the "Journal of the Royal Geographical Society," in which he claimed the whole of the mountain region south and east of Gebel Katherina as original. Mr. Holland had qualified himself for the task by travelling through the greater part of Sinai, but his traverses were too rapid for great accuracy, and it is not surprising that in a country of this complexity, he should have missed many of the most interesting points. While the direction of the great artery of Nasb, its bends, and its relations to Wadi Kyd are well displayed, the existence of the coastal watershed was not recognized, and Wadi Letih, instead of being connected with Um Adowi, is represented as draining southward, whereas it will be seen that a twenty-foot gravel ridge deflects it northward.

Unless this ridge be actually crossed, it would not be difficult for anyone mapping from a distance to fall into this error, which is repeated in the Admiralty chart. A comparison with more detailed maps will show clearly where Mr. Holland has been misled, but full credit must be given to him for his pioneer effort to portray this difficult district.

About the same period Sir Charles Wilson and Captain Palmer, accompanied by a band of enthusiastic workers, commenced a detailed survey of the reputed sites of Sinai and the probable route followed by the children of Israel, their results being embodied in two large general sheets, extending from Wady Gharandel on the north to Wady Isla on the south. Whereas these maps mainly embrace Western Sinai (exclusive of the country south of Tor) the surveyors did not carry their triangulations far into the eastern area, though such points as they have determined have proved most useful to the present expedition, these having been verified, and used as the basis for our own survey.

Although a few minor points of detail are open to criticism, especially in connection with the extreme eastern border, this map is the most valuable contribution to the study of the peninsula hitherto published.

Finally, the Admiralty sheets of Nares and Moresby are, as might be expected, admirably correct for the coast-line, but the map, which deals

with the Gulf of Akaba, errs in much the same way as Holland's, and probably for identical reasons. In fact, it may be safely said that no valley direction can be assured in this district, without its having been fully tested and proved.

CHAPTER II.

SURVEY METHODS AND GENERAL GEOGRAPHY.

The present memoir embodies the results obtained by the Egyptian Geological Survey expedition when working in Eastern Sinai. The geographical deductions which follow are based upon the topographical map prepared with much care by my colleague, Mr. H. G. Skill, F.R.G.S., the surveyor of the party. The plan of work adopted was briefly as follows:—From Tor to the mountains the distance traversed was determined by a measuring wheel, whose relations to a chain-measured kilometre had been previously tested. On entering the mountains this instrument had to be abandoned, the Ordnance stations of Eth Thebt, Fersh Sheikh-el-Arab, Abu Mesud, and Beidha being adopted as points on base lines, from which a plane-table triangulation was built up. This was carried across the peninsula to Nebk, on the Gulf of Akaba, when a fresh base-line was measured on the plain near that locality and from it the southern portion of the peninsula was similarly triangulated. A third base was measured near the foot of Gebel Haimar in order to map the southern higher ranges as accurately as possible. A final check-base was laid down at Dahab, this differing from the same line on the map itself by an inappreciable amount.

A comparison of the sheets between themselves shows the *maximum* error to be about half a kilometre in any direction.

In order to further reduce possible errors, observations for *time* and *latitude* have been made at all the principal camps, *time* being determined by east and west stars, and *latitude* by Polaris and at important stations by circum-meridian stars.

In addition to the preparation of the map, Mr. Skill has carried out a large series of observations for the more accurate determination of *heights*. (1) with hypsometer, boiled at all camps and on all principal summits. (2) with metre aneroid, used for camps only, to avoid strain due to mountain climbing and (3) with an aneroid, marked in feet, used mainly for the ascents. The heights are determined from these according

to their respective values. In one case also a round of angles was taken to principal peaks.

Whenever camp was fixed for a whole day, barometer readings were taken at intervals during the day and as often as practicable camps were located on the same spot for two days, so that any such pressure changes might be observed and noted. All the subsequent remarks on variations of temperature, wind and weather, &c., are based on observations made by Mr. Skill, the temperature being determined by sling-thermometer (Elliott). Thus at each principal station the following notes were made by him, *time*, *pressure* and *height* by inch aneroid, hypsometer reading, temperature, direction of wind, if any, and whether cloudy or otherwise.*

As a result of these observations Eastern Sinai may be divided into several regions, meteorologically distinct.

1. The western plains characterized by high temperatures, and on the coast by north-west winds.

2. The Central Sinai plateau, marked during winter by low temperatures and sudden storms, and in summer by comparatively temperate conditions, stillness of the atmosphere and clearness of the sky.

3. Southern Sinai, south of the transverse divide much cut up by valleys which are at a lower elevation than those of the plateau, the temperature being consequently higher in winter. Apart from sudden gusts, this is also an area of still atmosphere, except for gentle breezes in the afternoon.

4. The Gulf of Akaba coast-line. This region is one of the most wind-swept on the face of the globe, the north-easter blowing without cessation for days together, the result also being that the temperature is lower than in the plains on the western side.

As regards more detailed weather conditions, snow covers the highest peaks in late December and January and in the case of Gebel Sabbagh lay at least for three days. Hail was recorded once in February. For rain the country is entirely dependent on the local storms, and speaking generally, it was most common towards evening time, especially in the spring. The quantity that falls during a storm must be very great, but the party was never in the centre of one of the very severe type.

The mountain ranges evidently affect the rainfall, thus the central chain catches the south-west moisture-laden winds which come up especially in November. It is impossible in view of the small amount of vegetation to judge at what height the maximum fall takes place.

* For details see Appendix I.

Storms from November onward generally seemed to advance from the south-west, but in May the conditions appeared to be changed, a number of storms passing over Sinai from the north or north-west. The finest were noted in early November, in early March, and in May. With regard to wind effects, as different districts were passed over, it is difficult to give definite conclusions, but in general the stillness of the air is a marked feature in the mountain regions, especially at night or in the morning. In the afternoon, especially in spring, a light breeze prevails, but probably rarely exceeds a velocity of fifteen miles per hour. On the shores of the Gulf of Akaba, this rises to a velocity which may vary on an average from 35 to 50 miles an hour, i.e. moderate to fresh gale, and some movement of the air from the north-east is rarely absent.

From the 18th of January to the end of February westerly winds were frequent, mornings and evenings being clear and still, the western breeze rising in the afternoon. On some days, such as January 20th and 21st, sharp changes were noted during the day, a still morning being followed by north-east or south-east breezes about noon, while between 2 and 4 p.m. the wind had swung round to the west. Apart from the above period, north and north-east winds decidedly prevail for most of the spring months, though north-west winds held the upper hand in early June at Tor.

In conclusion, it is probable that the movements of the air currents are largely determined by the rift-structures of the country, many of the main valleys like Akaba, Raib, etc., having a distinct north to north-east trend. The wind entering them from the northern side is trapped as in a funnel, and follows the direction of the valley. In this connection it is significant that the records on the western side of the Red Sea indicate north-west winds as the most prevalent in spring.

The use of the compass in plane tabling had to be practically abandoned, the doleritic dykes which seam the country sometimes causing a variation from magnetic north of over ten degrees.

A brief remark may be made here as to the Arabs accompanying the expedition. The mountain staff consisted of two Ababda who had been with me in previous expeditions, Ibrahim Khalifa and Rean Abid, both of Qena, the first named being an especially expert climber. The Arabs of Sinai have maintained their reputation for honesty and readiness to obey, our sheikh, Ali Suliman, following his orders implicitly. We had the good fortune to be accompanied by one of the best guides in the country, Hudr Abu Merai, who is responsible for many of the names and much information; while in

the Letih district these were supplied by a younger guide, Hussein Abu Hassan.

With regard to the mountain climbing, our experience is the same as that of Sir Charles Wilson and the other members of the Ordnance Survey of Sinai, viz:—that no peak in Sinai is absolutely inaccessible. Our plan was to attack any mountain that was necessary as a station, however formidable it might appear, the attempt being in all cases crowned with success. One other point may be mentioned, viz:—the supposed dangers connected with an expedition in Eastern Sinai. There is no doubt that the Sinai Arab entertains a great dread of the dwellers on the eastern shores of the Gulf of Akaba, the inhabitants of Magna especially having a bad reputation. On only one occasion did we feel any necessity for sleeping under arms, this being due to several boats having put out from Magna to reconnoitre at Dahab, probably in consequence of their having seen our lights when we were taking some observations on a hill above the camp.

Interference by the Turks seemed also to be much feared, but though we worked far north of a line which the chief sheikh, Modakhel, had asked us not to cross, there was no suggestion at any time of danger from this quarter.

Illustrations.—Our special thanks are due to Herr Guyot, of Helwan, who kindly permitted us to use his photographic material for the purposes of this memoir, the views having been obtained by him during two scientific expeditions to Sinai. (See Plates II, IV, V, IX, XII, XIII, and XV to XVIII).

Dr. Grote, who has an intimate acquaintance with the peninsula, and has also formed a large photographic collection, has kindly permitted the reproduction of the plate which forms the frontispiece and Plate III. The remaining views were taken by the writer.

GENERAL GEOGRAPHY.

The traveller who enters Sinai by the quarantine port of Tor will, when standing on the shore and looking eastward, see a prominent mountain range running roughly north-west and south-east, and extending as far as eye can reach in both directions, only broken here and there by more prominent summits, among which the many-peaked Serbal in the extreme north, the dark plateau massif of Catherina or Zebir and the bold peak of Um Shomer opposite Tor, are especially

conspicuous. This great range is the western edge of the region which will be dealt with in this memoir and is itself a relic of a tectonic change of the first magnitude.

On crossing the hot and pebbly plain of El Qa'a (22·5 kilometres in breadth between Tor and Wadi Isla) in an easterly direction, the rugged range of mountains which apparently crosses the path appears impenetrable. No opening into the complex of hills is apparent, but wild valleys full of huge boulders descend steeply, until reaching the level ground they give rise to broad shallow watercourses meandering westward to the Gulf of Suez. One of these is the mouth of Wadi Isla, which for a distance of fourteen kilometres cuts through four important mountain barriers, forming a series of fine gorges, whose walls rise five hundred to a thousand metres above the valley. This groove forks at its eastern end, dividing into two valley systems, bent back parallel to the main watershed, the one, Wadi Tarfa, descending steeply southward between precipitous hills, while the other, Wadi Eth Thebt, broadens out at its southern extremity into a series of branches which end abruptly against the steep ridges of the Eth Thebt-Theman range.

Principal mountain chain and watershed and their relations.— Leaving these western valleys and ascending the peak of Fersh Sheikh el Arab at the head of Tarfa, or still better, the central mass of Abu Mesud, we obtain a general picture of both north-east and south-east Sinai, their boundaries, their principal summits, and their contrasts. The first fact that strikes the observer is that no second longitudinal chain of importance rises behind the one seen from Tor. Serbal is hidden by the dark plateau of Zebir (2600 metres), from whose summit rise a few isolated knolls, and which terminates in an abrupt wall to the south. Lower parallel ridges cross the country at the head of Wadi Rahabeh, terminating in the mountain mass of Um Shomer (2575 metres) this itself being the highest crest of the Rimhan range, which running south-east fills the angle between Wadi Rimhan and Wadi Isla. On the opposite side of the valley the thin ridge of Theman terminates in the conical peak (when seen from the north) of Gebel Eth Thebt (2403 metres), though the elevations of Theman and Eth Themnin are striking points rising precipitously from the same crest.

Main watershed. — Although the above ranges undoubtedly form the most striking mountain masses in the peninsula, including as they do its three highest summits, yet but few of them play any part in the formation of the central watershed. From latitude 28° 40′, a little north

of Sinai Convent, the latter runs on the eastern side of Wadi es Sheikh in a north-south direction, being formed by a comparatively low set of hills, the only summit of note on this line being Gebel Um Allowi or Derawi (2097 metres), Sinai proper (Gebel Musa) and Gebel El Deir being both left on the western side. The watershed crosses over the head of Wadi Sebaia at 1749 metres, but still maintains its northern trend. Here only is it formed by the main mountain system, the Zebir plateau in part draining to Wadi Nasb. At the head of the latter wadi, the plain of Rahabeh, it has a marked bend from Muharrig under the slopes of Um Koli running in a south-west direction, then turning south-east and finally east along the ridge of Abu Shejer and across the Tarfa Pass to Fersh Sheikh el Arab in such a way as to leave Um Shomer and the Rimhan crest also on the western side. From this point the watershed again resumes its north-south trend, joining the main mountain system at Gebel Eth Thebt.

From the above it is seen that the main mountain range from Sinai to Eth Thebt does not agree with the central watershed, but that the latter generally lies a short distance to the east of it.

Returning to our central summit of Abu Mesud, and looking southward, the central chain is seen to detach itself into several marked elevations more or less separate one from the other. For example Eth Thebt is part of a distinct mountain wall, immediately behind it rising the twin summits of Ethmid, themselves closely connected with the long thin crest of Halefia, and all being over 2000 metres in height. A marked notch separates these hills from a *sierra* (using the Ordnance term) or knife-edge range, which has its highest point, Gebel Sabbagh or Um Hash (2256 metres) near the northern edge of the crest, and whose two main summits when viewed from the north have a peculiar truncated step-pyramid appearance.

The character of the southern peaks cannot be determined from our selected summit, but south of Sabbagh the main mountain mass is no longer a single high range with lower ones on the east of it, but a double system of equal altitude, Gebel Ethnarbi or Jerjir being immediately west of Gebel Um Adowi, and both rising about 1869 metres above sea-level ; while still further to the south, the serrated Haimar-Hamar range, flanked to the west by the ridge of Sahara, maintains the duplicate character of the mountain scenery. West of Sherm the conditions are more complex, the hills sink below the three thousand-foot level, while preserving for a time their precipitous outlines, until finally they merge into the lower granite country and raised coral reefs which terminate in a 122-metre cliff at Ras Mohammed. Briefly, the map shows

the main mountain chain to consist in the north of long thin crests whose summits are from 2135 to 2438 metres in height with secondary chains very inferior to them, while south of the Um Adowi Pass the hill system becomes more complex and duplicated, the spurs rivalling the principal ranges, and the heights symmetrically diminishing from 1829 metres to 610 or less.

The watershed only follows the main chain a short distance south of Eth Thebt along the Ethmid, Halefia and Sabbagh ranges. In the centre of the latter it suddenly leaves the higher ridges and follows a lower slope, subsequently meandering among the western hills in such a way as to leave Um Adowi, Ethnarbi, and the great mountain mass connected with them on the east side of the line, and only meeting the principal axis in Gebel Sahara. From the Sahara-Aad line onward, it runs in such a manner as to have the long mountain slopes on the west, while the spurs, now higher than the watershed hills, are all again found on the eastern side.

Thus the main mountain line from Eth Thebt to Ras Mohammed seldom agrees with the central watershed, but the latter in the main lies to the west of it.

Character of principal summits on main chain. — The character of the principal hills of the main chain are as follows:— Gebel Zebir-Katharina. Though actually the highest mountain in Sinai (2602 metres Ordnance) this massif is easy of ascent, being less than 915 metres above Wadi Sebaia and showing the comparatively easy gradients of the schistose hills when not traversed by many dykes. At the summit it forms a broad plateau, studded with low conical hills, to which separate names are given, and three of which have been used as Ordnance stations. It stands in sharp contrast to Um Shomer (2572 metres) which instead of being dark-coloured like Zebir, is of the light granite tints and has a bold and striking outline, forming one of the most notable mountain features seen by travellers going down the Red Sea. It has been less frequently ascended than Zebir, as the ridge of Abu Shejer has first to be scaled and a steep descent made on the other side before the main peak is attacked. The Rev. F. W. Holland, who ascended it twice, states that there is no difficulty, except close to the summit, where it is necessary to remove boots. The twin peaks of Rimhan close by have also served as Ordnance stations, and are probably not difficult of access from Wadi Rimhan. Gebel Eth Thebt (2403 metres) is again a different type of mountain, felsite dykes forming steep precipitous sides being apparently in close contact one with the other. This, combined with the

rolling stones, renders the ascent difficult and tedious, and Mr. Holland who was the first to ascend it took four hours in reaching a height of less than 915 metres.

The two Ethmids and Halefia are probably as yet unconquered. They have to be approached by difficult mountain valleys, full of boulders, and with the higher summits of Eth Thebt and Sabbagh on both sides are of no special value as stations.

Gebel Sabbagh or Um Hash (2256 metres) has been first ascended by the present party. Though over 305 metres lower than Um Shomer and Zebir, it is nevertheless relatively almost the highest mountain in Sinai, being on all sides over 1220 metres above the camping grounds. The approaches are not specially difficult, though the boulder valley is of some length, while the numerous precipices can be rounded. The chief drawback to our ascent was the snow which lay thickly in places, some of the Arabs being severely frost-bitten in consequence.

Gebel Um Adowi though only 1830 metres high is nevertheless 1220 metres above the valley. This again has been ascended for the first time by our party. Here advantage has to be taken of the worn-down dolerite gullies and steep valleys, as otherwise the mountain, especially near the summit, is extremely precipitous. In fact most of the granite hills share this feature.

Gebel Ethnarbi, which is easier than the above, has also not previously been climbed. The ascent of Gebel Sahara has been made by Mr. Holland and by ourselves, while a cairn on Gebel Haimar shows it to have been previously scaled by some unknown traveller. This is one of the most difficult of the principal hills, unless attacked by a gully on the southern flank, whereas Gebel Aad, apparently not previously visited, was comparatively easy.

Aad El Gharbi, terminating the range, was also ascended by Messrs. Barron and Hardwick from the western side. Speaking generally, the mountains are characterized by the numerous precipices, by the narrow, often saw-like character of the ridges, and by the boulder-strewn nature of the valleys and gullies which descend from them.

Passes. — The above ranges which trend for a distance of over fifty miles in a north-east and south-west direction are traversible by baggage camels at three points only south of Wadi es Sheikh. The most northerly is the break between Gebel Rimhan and the Theman range formed by Wadi Isla, which leads directly to two passes. One of these, the **Tarfa Pass**, connects Wadi Tarfa (running parallel to the main **watershed** on the western side) with Wadi Rahabeh, and being the

main road from Tor to the great east-and-west artery of Nasb, is of vital importance to the country. The second one joins Wadi Eth Thebt with Wadi Humr, and is only available for lightly-laden camels. South of this point there is not even a footpath till the head of Wadi Letih is reached, though there are breaks at the head of Jerjir and Um Hash which are traversible by foot. At the head of Letih are two passes, the one into Budr used for sheep only, while that into Tehih is available for lightly-laden camels. There is a footpath from Letih to Wadi Rasheh and a riding camel (hagin) pass from Aad to Aad el Gharbi, but baggage camels coming from Tor to Sherm cannot cross the hills until Wadi Hashubi is reached. This is a very easy passage, but there is a second a trifle more difficult to the south which also enters Hashubi.

Returning to the centre of the peninsula, and standing on the summit of Sinai, the view to the east is not very striking. To the north-east the long white limestone wall of Gebel Gunna extends in an east-and-west direction, still further to the east breaking up into separate masses, and ending with the fine, truncated cone of Gebel el Ain. Further south spreads a flat or undulating granite plateau, out of which the Derawi-Er Rogha ridge, the dark peak of Habshi, and a few lesser heights, rise as isolated projections. To the south-east extends a mountain wall, which hides all the southern land from view. It is with this transverse divide that we have next to deal, constituting as it does the most important secondary mountain mass in the country, and forming a definite boundary between two different types of scenery.

The principal transverse watershed and the divide are identical at many important points. The latter unites with the central watershed at Fersh Sheikh el Arab (2152 metres) which together with Abu Mesud (2110 metres), forms the northern wall of a deep depression, the Fera el Adhal. Abu Mesud is one of the most prominent points in the peninsula, a dark cap rising from a plateau of some extent which is over 1830 metres in height, and is bounded on the southern and eastern sides by striking precipices of red granite. The watershed descends the north-east slope of Abu Mesud and then passes among lower hills leaving the fine white Gebel Beidha (1756 metres) and the many-peaked Ashara hills to the north of the line. Broken by two depressions subsequently to be described, the divide is continued in the Ferani chain, which is 1220 to 1677 metres in average height, and rises 915 metres above the surrounding valleys. In this half of Eastern Sinai both watershed and mountain chains show a curvature, being alternately convex to north

and south respectively. The result is the production of an amphitheatre bounded on the west by the Ferani range, on the south by the Gebel Um Malaga and its allies, and on the east by the shorter limb of Gebel Gnai and the associated coast range. To this I have referred as the Dahab amphitheatre.

The characteristics of the main transverse divide and watershed are:— (1) Gradual lowering of the range heights from west to east from 2135 to 915 metres, (2) Striking curvature of the watershed line, contrasting strongly with the comparative straightness of the main watershed.

Fersh Sheikh el Arab, Abu Mesud and Beidha have been previously ascended by the Ordnance Survey, and one of the lower Ferani hills had also a cairn on its summit, but all the others mentioned above or shown on the map as stations have probably been now visited for the first time.

Passes over transverse watershed. — There are only five possible ways over this divide, the first one between Fersh Sheikh el Arab and Abu Mesud being a riding-camel path leading into Fera el Adhal. Another is a steep pass leading from Um Rachal into Wadi Amlagh, in both the above cases the whole drop being on the south side. A third pass is an easy one for baggage camels from Wadi Shelala (on the western side of the Ferani range) to Rahab across a Nubian sandstone terrace only 92 metres high. The fourth is on the eastern side of the Ferani hills connecting Wadi Um Athaga and Lij, while the fifth, the Sharafa Pass, is the main route for baggage camels from Dahab to Sherm.

There is a remarkable feature common to all these passes, viz: *that the valleys they connect form five roughly straight lines, all parallel to one another and to the Gulf of Akaba, that is in a direction somewhat west of south.*

Within the area defined by the mountain walls of the central and transverse ranges are a vast number of hills, either running as long spurs projecting from the barrier range such as that of Gebel Mazea (Um Kheisen) and Genaui; as elevated plateaux, such as the Fersh El Gasab with the peaks of Genaui and Um Ekhlis rising from it; or as isolated peaks, such as Gebel Barakat.

Coastal watershed. — There is in addition a topographical feature of primary importance, a watershed line running close to the coast of the Gulf of Akaba, broken only in two places by the Kyd and Um

Adowi valleys. This line is formed by an almost continuous series of rugged ridges from 610 to 915 metres high, traversed by mountain passes in the main absolutely impassable for camels. Only at Wadi Gebila is there an easy passage to the gulf. South of this point the hills rapidly lessen in height, and the striking character of this coast watershed disappears, though in the twin hills of Themain and Ajuaf it again attains a height of 915 metres and deflects Wadi Letih into Um Adowi, finally ending in the summits of Gebel Haimar and Hamar (1382 metres) which project from the central mountain chain.

Between Ajuaf and Haimar it is formed by a gravel terrace only 6 metres high. Most of the hill ranges close to the coastal watershed are running at right angles to the latter. The country outside these three watersheds is composed either of comparatively low hills, in many cases isolated, or of coastal plain, which latter, however, is never of any great width.

Dyke country. — Although within the triangle formed by these three watersheds the district is largely composed of high ranges, yet in the south-eastern part, owing to the greater progress of denudation, a special type of structure has been produced, giving rise to what we may term "dyke-country." This consists of a series of ridges, due to felsite and dolerite dykes, running parallel to one another and separated by small valleys, the elevations varying from one hundred to about three hundred metres. Such a district occurs between Wadis Letih, Um Adowi and the Um Adowi mountain range, while another topographically more complex because two sets of dykes cross each other, fills up the interval between Wadis Kyd and Um Adowi. A third region of the same nature lies to the west of Dahab, bounded by the Nasb rift on the north, by the Ferani range on the west, and by those of Um Malaga and Gnai on the south.

Although the dykes are particularly striking in the above-mentioned dyke-regions, yet their influence in the determination of mountain form is to be traced throughout the peninsula, the summits of many prominent peaks being formed by felsite dykes, and like the latter having a marked north-east and south-west trend. This is especially the case in the hills immediately north of Wadi Nasb, and in the schistose district between Dahab and Nebk.

Geological composition has played an important part in the formation of some of the higher ranges. The summits of Zebir, Abu Mesud, the Ferani range, and Habshi, are composed of dark felsites which seem to have acted as hindrances to denudation, preserving the underlying

granite, and in the same way the schistose region with which the dark felsites are closely associated is on the average higher than the granite country which extends to the south and west of it.

As already stated the transverse divide separates two distinct types of country, the whole district on the south having been exposed to the intense action of denuding agents, while to the north of it the plateau structure is still to a large extent preserved, the granite having apparently only recently lost its capping of Nubian sandstone. Nevertheless the impression left on the traveller who keeps to the valleys north of the divide will be very different from the reality. Hour after hour he will find himself wandering between steep mountains, which rise from 467 to 610 metres on both sides of the gorges, and only after ascending these by steep gully and rocky slopes will he realize that the valleys are but deep clefts in a comparatively flat surface, though the dykes and minor ravines are already having a marked effect on the general character of the scenery. Owing to a low northern dip of 2° to 3° the overlying Nubian sandstone and Cretaceous limestone come successively to the surface, producing characteristic scenic features in each case. Wherever present the white grits of the Nubian sandstone give rise to remarkable isolated outliers, bounded on all sides by almost vertical walls, between which the valleys meander in labyrinths, curves and twists. At other points, the grits have disappeared and the basis of hard ferruginous sandstone on which they rest forms the broad sandy plains of Barga and Huthera, or flat plateaux such as Ejjibi, etc. To the south the sandstone forming at first a thin covering to the granite breaks up into isolated patches, which stand out prominently on the summits of Er Raimshi, Kharaza, and the neighbouring hills. The district mapped is bounded by the Cretaceous limestones which overlying the Nubian grits produce a long plateau facing the south with a very marked escarpment which is deeply cut into broad bays. These beds, as already related, do not reach the gulf, but terminate in the isolated tabular or truncated cone of El Ain, between which and the Gulf of Akaba is a complex of granite hills among which rise lighter isolated masses of sedimentary rocks. Far in the distance to the north a second limestone escarpment is visible, but this has not been visited.

Thus far, the country north of Nasb has been described in its simplest form, but a glance at the Ain el Hudera sheet (see Plate XXII) reveals the fact that the structure is far more complex than can be explained by mere geological succession, in fact on our northern boundary the map becomes a chequer work of intermixed scenic features, due to the limestones, sandstones, and granite respectively.

To the east of Wadi Ra'ib runs a bold wall of granite stretching to the northern watershed, behind which the country is hidden from sight. Standing on a central summit in the southern part of the sheet, * the observer finds himself face to face with a bewildering complex of topographical structure. In front lie the flat red-brown sandstone plateaux of Ejjibi, Abu Ghirsh, and Um Rowa, close underneath whose surface red granite walls are easily distinguishable. To the north-west granite ridges rise abruptly from between sandstone areas, or lie side by side with green-coloured limestone hills. To the west the green summit of Um Raiyig just appears above the Nubian knolls, while scattered here and there stand the vertical brownish pink outliers of sandstone, Gebel Barga, Amutamir, Jenach, and Ikri. Finally to the extreme north, the hills of Room el Seraier and El Hudera are isolated from the Gunna plateau to which they evidently belong.

As will be seen later the mystery of the hill distribution is easily explainable, for before us lies not merely a region where quiet deposition and elevation has alone played a part, but a land which has been the scene of dislocation and deformation, of rift and rent, and on which denudation has finally placed its seal and impress.

Summary.

Excluding the valleys, the surface features of the country are due to:

1. Geological structure, in which the following elements play part.
   - (a) *Cretaceous limestone*, giving rise to the main escarpment with plateau summit, and numerous isolated green hills in the north.
   - (b) *Nubian sandstone*, whose white grits produce a vertical-walled cliff under the Cretaceous plateau, or perpendicular-sided outliers weathering in a series of platforms. On the other hand, the lower ferruginous sandstones give rise to isolated flat plateaux or broad sandy plains, or form caps on the surface of the granite.
   - (c) The *granite* north of Nasb is plateau-like, having only recently lost its cap of sandstone.
   - (d) *Dark felsites* have, by their resisting power to denudation, given rise to several of the most important mountains in the peninsula.
   - (e) *Dykes* of red felsite and dolerite have been instrumental in producing a number of ridges and mountain chains, many of them having the same trend as the majority of the dykes, viz: from north-east to south-west.

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* See Plate XXII.

2. *Dislocation and fracture.*—These have been responsible for :—

   (f) *Production of main chain* by a fault with a proved throw to the west of over 5,000 metres, parallel with the border of the Qaa plain.

   (g) *Probable production of transverse watershed.* This latter being generally parallel to the transverse fracture between the Red Sea and the two gulfs of Akaba and Suez.

   (h) *Existence of coastal watershed*, which is in general parallel to the Gulf of Akaba.

   (i) *Complexity of geological structure in northern sheet*, * which is due to two main rifts running parallel to the Gulf of Akaba, and a number of minor fault systems.

3. *Denudation* has further been active in, or has caused:

   (j) The production of curious rounded knobs and pillars by the wearing away of the granite in shells, and generally the rounded outline of many granite mountains.

   (k) The existence of many of the serrated and knife-edge ridges characteristic of the country, denudation having been active on both sides till a crest is produced from which the water immediately flows off.

   (l) Remarkable hollows in the granite itself, whose mode of origin is still doubtful.

Valley Systems.

Even a superficial glance at the map is sufficient to show that the valleys present a regular arrangement which is quite unusual in most countries, the east-and-west drainage systems being crossed by long north-and-south depressions, whose straight-lined character is very noticeable, while at the same time a minor branching of a very complex nature adds to the difficulty of interpretation. The main valleys will here be considered separately in relation to their principal features only. They run very definitely in two directions almost at right angles to one another, viz :—west to east, and north to south, but at the same time present certain remarkable features demanding special attention.

East and west valleys.

Wadi Nasb.—The longest and most remarkable of all the Eastern Sinai wadis is Wadi Nasb, which runs from the central watershed to

* See Plate XXII.

the Gulf of Akaba at Dahab, a distance of 80 kilometres. For the first forty kilometres it trends nearly due east and west, cutting through two fine gorges on the way, but then is suddenly barred by hills rising from 366 to 915 metres above valley-level. As a result the valley turns abruptly northward for 16 kilometres, at the end once more resuming its eastward trend, and again forming a fine ravine which is more or less marked for the next thirteen kilometres, when the wadi turns southward almost parallel to its northward trending arm. Wadi Nasb receives the main part of the drainage of north-east Sinai, with the exception of a small strip drained by Wadi El Ain (and its tributaries) which opens out at Noweiba. The peculiar rectangular deviation above-mentioned is closely connected with two "rifts" whose geological and topographical importance will still further have to be emphasized.

Wadi Kyd.—Whereas the whole of the country drained by Wadi Nasb, about 2800 square kilometres, is only situated to the north of that valley, the feeders on the south being insignificant, Wadi Kyd, the most important valley in south-east Sinai, receives notable branches from both north and south. The actual Wadi Kyd rises in the basin-shaped amphitheatre of Fera El Adhal, (which is surrounded on all sides by mountains 1525 to 2135 metres high) and leaves it through a deep narrow cleft, which only opens out near to the point where Wadi Um Gerat joins it from the south. The latter valley is itself a combination of several draining the high mountain region of Eth Thebt and Humr, the most prominent being Wadis Humr, Ethmid, and Jendeli. The east and west direction of Wadi Kyd is continued until it is joined by the north and south-trending Wadi Melhadge, at this point still retaining the name of Kyd it is deflected due south for some miles, again turning east before entering the Gulf of Akaba. To the north of Wadi Kyd there is also a very complex group of valleys draining the northern wall, and opening into a single artery, Wadi Madsus, which itself enters Wadi Melhadge not far north of its junction with Kyd. Close to its final eastward bend Wadi Kyd receives another series of valleys draining the ranges of Halefia and Sabbagh, as well as the high plateau of Genaui, the principal branch being Wadi Yahamed. It may thus be truly said that Wadi Kyd drains nearly half the south-eastern portion of the peninsula. Rev. F.W. Holland, M.A., whose sketchmap of this district published in the "Journal of the Royal Geographical Society," 1868, is the only authoritative record of its topographical character, has also made the next big valley to the south drain into Wadi Kyd, but this conclusion is erroneous, and is due presumably to the rapidity of his traverse.

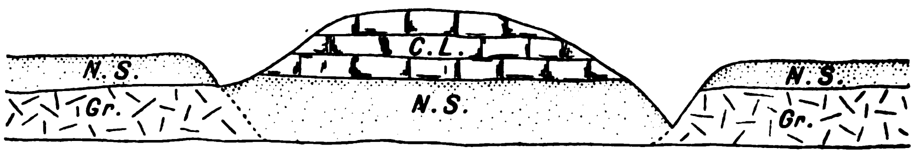
Wadi Um Adowi.—Wadi Um Adowi, which takes its rise in the hills behind Gebels Sabbagh and Um Adowi, stands in contrast to the two valleys above mentioned, because nearly all its principal feeders come from its southern side. The valley itself runs almost due east and west without any prominent bend. Its principal tributary is Wadi Letih, which taking its rise near the foot of Gebel Budr, for the first part of its course runs between the wild and rugged mountains of Sahara, Hamar and Um Zeynig, all over 1,220 metres high, on the north being the mountain masses of Ethnarbi, Um Adowi and Mandar. For the first part of its course it runs east and west, being then deflected northward by a low gravel ridge.

Wadi Aad.—The southern part of the peninsula is drained by valleys which receive but few tributaries, the principal of these being Wadi Aad, chiefly notable on account of its important water supply; Wadi Madsus, which towards the upper end turns completely at right angles to its initial course, a feature shared by several of these southern valleys; and Wadi Hashubi, which forms an easy road for baggage camels from the western plain to Ras Mohammed and the plains of Sherm. The reasons which have led to the distribution of these east and west valleys can only be inferred by analogy, but the origin of the north and south valleys with which we have next to deal is by no means so obscure, and can be directly traced to dynamical changes whose character, extent, and possible age may be more or less accurately determined. They belong in fact to the category of rift* valleys, of which the Gulf of Akaba is itself a striking example. It must be remembered that these are not single depressions, but rather a series of basins separated by areas which though higher than the main valley are of no great altitude compared with the bordering hills. Thus in the Great Rift valley the Dead Sea, Lake of Tiberias, Gulf of Akaba, and at the southern end Lakes Rudolph, Tanganyika, and Nyassa are all examples of such basins.

Um Raiyig-Shelala rift.—There are two main valley-systems of this kind in Eastern Sinai, and both extend far north of the south-eastern district. The first or Um Raiyig-Shelala rift, commences on the very edge of the escarpment of Gebel Gunna, in the extreme north of the Sinai region, but becomes prominently marked at a point where the

* These valleys would be better described as trough-fault valleys; where the word rift is used in this memoir it must be understood in this sense.

limestone hill of Gebel Um Raiyig is wedged in between two granite ridges.



(Fig. 1).

To the south of this hill there is practically a continuous north and south valley, broken only by low and insignificant passes, and running far into the centre of the south-eastern district. Consequently there is an easy road down Wadi Um Raiyig to the north-trending portion of the loop of Nasb and Um Shelala, which again is separated by a low pass 91 metres high, (due to sandstone let down between the igneous rocks which rise 610 metres above it), from Wadi Er Rahab and the cross-cuts of Khlalat and Ekhmoin, the whole running almost at right angles to the main drainage valleys of the district. On the southern side of Wadi Kyd, Um Zegir continues this line, the rift only finally disappearing as such in Wadi El Tema. The main characteristics of the Shelala-Um Raiyig rift are:—

1. Its length, being about seventy-two kilometres long.

2. Its almost perfectly straight character, there being only a slight bend where Wadi Nasb turns east at the mouth of Um Raiyig.

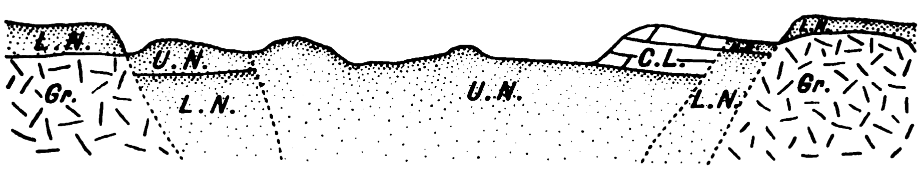
3. The steep slopes of the bounding hills throughout the greater part of its course.

4. The occasional diversity of geological structure on both sides, especially marked where it separates the granite range of Ashara from the felsitic hills of Ferani.

5. The letting down of younger beds along the line, so that strata have been displaced from 200 to 600 metres at least, the result being that both Cretaceous limestone and Nubian sandstone exposures occur far south of their main outcrop.

6. The presence of older granites surrounded by the younger sedimentary rocks.

Raib-Melhadye rift.—This second rift has again a striking effect on the features of the country, and is longer than the previous one; but does not have marked rift characters throughout its whole length, though sufficient for Russegger's map to show it as an unbroken valley extending from north of Dahab to near Nebk. The first point that strikes the traveller going from Ain El Hudera to Dahab through Wadi Raib—erroneously named Wadi Zal by Holland—is the fact that the granite range extends far further to the north on its eastern than on its western border, a feature well brought out in Russegger's map. The eastern and western sides of the upper part of this valley are also in sharp contrast, the former being a continuous steep wall, while on the west the country is geologically far more complex, and has clearly undergone considerable disturbance. Cenomanian limestone ridges and plateaux of Nubian sandstone, the latter capping masses of granite, succeed each other in a way that shows the whole to be the result of folding and step-faulting.



(Fig. 2).

Thus in one place, a side valley, Wadi UmRowah, the features present are seen to be due to the breaking down of an anticlinal fold, the centre having been step-faulted. On both sides of the valley are low granite slopes—G.N. (see Fig. 2)—capped by the dark-red sandstones here named Lower Nubian—L. N.—at the foot of the cliff being lower plateaux of the same rock. The centre of the valley is occupied by rocks of much younger age, ridges of Cenomanian limestone—C. L.—and the white grits of the Upper Nubian—U. N.—being present below the level of the granite in the bounding walls. To produce this result there must have been a deplacement of at least 200 metres. In the valley itself the result is still more striking, for there Cretaceous limestones form a low ridge dipping steeply eastward towards the granite which rises immediately above it to a height of over 300 metres. Descending

Wadi Raib the conditions become simpler, and the nature of its origin becomes more and more evident, the Nubian sandstone on the west giving way to granite cliffs, and the valley becoming a broad highway bounded on both sides by precipitous heights. Yet scattered all along its course are low hills of white Nubian sandstone, and in one place Cenomanian limestone, the surprising result being realised that Cretaceous fossils are collected from a limestone on both sides of which tower granite cliffs to a height of over 500 metres, the extent of dislocation being here at least 700 metres.

There is thus no question that Wadi Raib and its extension in the eastern loop of Wadi Nasb is undoubtedly due to a trought-fault, while its parallelism to the Um Raiyig line and the Gulf of Akaba shows them to have all been formed as part of the same movement. At the mouth of Wadi Abuksheib, where the last Nubian outlier—a fine mass 100 metres high—is met with, and beyond that point, the fissure character disappears in the low granite country, though the valleys forming the main road to Sherm run parallel to the Gulf of Akaba, and are the only ones available for camels. At the head of the Wadi Gnai, which trends north and south, the transverse divide is crossed by a low pass, from the south of which extends the long and narrow furrow of Melhadge cutting in a straight line through a dark range of metamorphic hills, which rise on both sides to heights of from 300 to 500 metres. The north and south-trending depression can be traced as far as and including a portion of Wadi Letih, broken only by the insignificant transverse divide of Wadi Merari.

Three other valley-systems parallel to and agreeing in all main characteristics with the two above mentioned cannot be excluded from the rift category.

Hammam-Lij rift.—The first of these, about midway between Wadis Nasb and Raib, from two of the dominant valleys may be termed the Hammam-Lij rift. To the north it disappears in the faulted plain of Barga, but becomes at once evident in the granite range, forming the deep grooves of Hammam and El Araish. Crossing Nasb, it is continued up the western branch of Wadi Gurna across the Gurna pass, and then taking the same slight bend westward as the Gulf of Akaba at Dahab, or the Um Isma-Melhadge system with regard to Wadi Raib, it turns west of north; broken only by a low pass between wadis Um Shoka and Abuksheib it is continued up Um Athaga to Wadi Lij, and thence with slight bends to Saiamin and Madsus. In the latter valley the straight-line character altogether disappears, and assuming a south-east

PLATE II. (a)

FAULTING IN IGNEOUS ROCK REGION.
WADI SABAIYA

PLATE II. (b)

FAULTING IN SEDIMENTARY ROCK REGION.
WADI BUDR

direction, it runs into Melhadge a little north of the junction of the latter with Wadi Kyd. The view that this line is a rift is strongly supported by the fact that a small patch of Nubian sandstone is let in between the felsites on the pass crossing from Um Shoka to Abuksheib.

Two other marked valley-lines run parallel to the Nasb-Rahab groove, and though direct evidence is wanting, there can be little hesitation in regarding them as of the same origin. One of these is the Um Ghirat—Um Rachal system, whose full extent northward has yet to be traced, the second, the Hagar-Arras valley, which may be continued through Nasb to Jow, though this last is the most hypothetical of any. They both agree in having their southern termination at Wadi Kyd, and a marked sudden drop to the south at the transverse divide.

Origin and Correlation of East Sinai Rifts with those of Neighbouring Districts.

As the eastern rifts are but parts of a complex system, it is necessary to consider their relation to those on the western side and in regions immediately adjoining, before their age and origin can be adequately discussed.

El Sheikh-Tarfa rift. — Glancing at the map of the Ordnance Survey an important line is observable running close to 34° east long. in a north-south direction, which extends over 20′ of latitude, and is throughout traversible by baggage camels. The explored portion of this depression opens in the north with the remarkable break of El Watiya, a cleft across a solid wall trending slightly east of north. From here Wadi El Sheikh runs southward in an almost perfectly straight line, and from its continuation in Wadi Sebaia an easy pass leads into Wady Rahabeh, and another forms a connection with Wadi Tarfa. At the junction of the latter with Wadi Isla the straight character disappears, but Wadis Eththemnin and Theman joined by a narrow col, are not far removed from the dominant direction, and may possibly be referable to the same movement. On the west of the El Sheikh-Tarfa rift the Ordnance map shows plainly that there is a similar succession of connected valleys, but their trend is entirely different from those on the eastern side, i. e., the Akaba or north-north-east has been replaced by the Suez or north-west-south-east type. Such a line is roughly outlined from Wadi Entish through Wadi Sheiger and Hargus, but a particularly striking example is the one which commences with Wadi Suwig in 29°.2 north latitude and runs almost unbroken through

Khamila, the head of Taiyiba, Bark, Lebwa, Berra, across El Sheikh, and through Wadi Sahab, while beyond this point low hills carry on the road to Wadi Solaf. Here the line meets the remarkable granite ridge which bounds the Sinai mountain region on the north. It is of the highest interest to find that the Nagb Hawa pass, the only other entry into the Sinai region besides El Watiya, is precisely on its prolongation, while the rift is further continued in the plain of the Law (El Rahab), the Convent valley, and across the easy pass between the precipitous slopes of El Deir, Sinai, and the hill of Moneija, till it finally terminates at the point where it meets the El Sheikh rift previously described. Sufficient has been said to show the important contrast in direction displayed by the rifts on the two sides of the 34° long. line, and as Mr. Barron has made a careful study of the whole western district it will not be further necessary to consider the other valley-systems and the borders of the Gulf of Suez in connection with rift action.

How completely the existence of these dislocations is unknown is best shown by a study of a summary of our present knowledge brought together by Dr. M. Blanckenhorn, under the title, "*Die Strukturlinien Syriens und des Roten Meeres,*" in the Festschrift in honour of Baron von Richthofen, Berlin, 1893.

In considering the origin of these structures, the field of discussion is a wide one. J. Walther in "*Die Korallenriffe der Sinai-halbinsel,*" (p. 439-440, Vol. XIV. Abhand. Math-phys. Classe, Konigl. Sächs. Gesell. der Wissenschaften) has, basing himself on the Admiralty charts of Nares and Moresby, called special attention to the three-fold character of the Red Sea, Gulf of Suez, and Gulf of Akaba respectively. Each of these are now universally admitted to be rifts, but rifts of different age and different character. The Suez type, as we have seen, is of wide importance, it determines many of the Western Sinai valley-systems and the outline of the main mountain chain. On the western side of the gulf it has been instrumental in producing the parallel outlines of the lower chains in front of the Red Sea hills, and at the same time has been the cause of the precipitous and straight boundary of the Red Sea hills themselves. Though still requiring mapping, it probably is the origin of the longitudinal drainage in the Red Sea hills west of Abu Harba, Dokhan, and the Gattar ranges, and may be found to extend far north parallel to the main chain. Nor is it difficult in a glance at Zittel's geological map of Egypt to recognise the general parallelism of Wadi Qena and even in part of the Nile valley itself to the dominant trend. On the east of the north-south El Sheikh line, as has been seen, the Akaba type is alone present, so far as our studies are concerned, but further north towards

PLATE III.

PLAIN OF THE LAW (EL RAHAB).

Akaba the faults drawn by Hull are of El-Sheikh character. On the eastern side of the Gulf of Akaba the fine precipitous ranges of Midian visible from Sinai, with the broad plain which runs parallel to them, must in all probability have the same character and origin as those previously described, but are not at present easily available for scientific investigation.

There is a third type of dislocation which has not yet been discussed, but which nevertheless may play a not unimportant part in the structure of the peninsula. Attention has been called by Walther (loc. cit. p. 440) to the remarkably sudden increase in depth south of the straits of Jubal, joining the Gulf of Suez and the Red Sea, and a similar sharp difference is noted with regard to the Gulf of Akaba, though not so pronounced as in the previous case. Blanckenhorn (loc. cit.) in his map shows a distinct transverse fracture south of Tiran Island, and Hull has drawn similar east and west faults at right angles to his north and south displacements. Turning to Eastern Sinai, attention has already been called to the transverse divide which separates two distinct types of country, standing at different average levels, and which may be due to a similar dislocation. It is difficult also to understand several other features, unless they be directly ascribed to transverse movements. On such a hypothesis the Haimar spur is easily accounted for, the watershed between Um Adowi and Kyd explained, and in the case of the elevation of Gebel Safara near Sherm, a transverse fault of importance is practically proved to exist. Although not possessing the convincing character of the evidence for north and south rifts, the existence of transverse dislocations in the peninsula itself may be postulated as *a first approximation* to the truth.

CONCLUSION. *It has been shown from the above remarks that the main features of the Sinai Peninsula have been produced by dislocation rather than erosion, fracture in three directions, either directly proved or in the highest degree probable, having determined the general structure of the country.*

Regularity of the valleys. — For another topographical problem the same explanation may suffice, though at present the precise method of solution is absent. This is the regularity of the valleys.

Directions. — Of 25 principal valleys (excluding those traceable to north-south rifts), which cross the eastern side of the peninsula, 17 show a south-eastward trend and in Wadi Letih the same direction is twice repeated, alternating with two bends of north-east type. Six

others follow a north-east course, being situated north of the divide, and west of the Nasb-Shelala rift, against which they terminate abruptly. In fact, the following generalization will not be far from the truth, 1st, that in the space between the divide, the El Sheikh and the Nasb rifts the valley directions are normally either slightly east of north-west of south *or north-east;* 2nd, in all other parts of the eastern side of the peninsula the dominant valleys trend east of north-west of south *and south-east.* In sharp contrast to these are the dominant lines of the valleys on the western side which are either north-west—south-east or south-west. We are unaware of any such regular arrangement in the backbone of any other mountainous country.

General level. — A good idea of the character of Eastern Sinai may best be derived from a brief statement of the proceedings of the party and the heights ascended, as determined by the inch barometer and hypsometer. The survey was carried out for 212 days, out of which 27 were rest days, that is to say, either shifting camp over ground previously traversed, delayed by bad weather, for inking maps, or other inevitable causes. Twelve days were spent more or less in the low plains, 23 days in valley-work, most of these in the earlier part of the traverse, a short experience proving that without ascents little efficient progress was possible. During the traverse nearly 150 ascents of more or less importance were made, and an examination of their heights will give the best clue to the differences in comparative level of the country examined. Adopting this method the total amount ascended was, excluding double stations, 65,422 metres, or an average of 309 metres per day. If the 143 summits alone be considered, the average high station ascent is 457 metres. The heights above valley level are subdivided as follows:—

On or above	4000	feet..........	(1220 metres) =	2
»	3000	»	(915 metres) =	10
»	2000	»	(610 metres) =	25
»	1500	»	(457 metres) =	36
»	1000	»	(305 metres) =	39

Turning now to the consideration of these in turn, the two results above 1220 metres give the actual level, the height of Sabbagh being measured from the highest point in the boulder valley where it was

possible to pitch a camp, while the ascent of Um Adowi was similarly made direct from the valley. Eth Thebt would be still higher relatively to its southern side, but the summit is nearer to valley level on the northern side.

The only mountain on the western side that can at present be included in this category would be the fine peak of Gebel Serbal, whose summit is 1433 metres above the Ordnance camp point, though possibly if figures were available Madsus and Tarbush would also be included. In fact Messrs. Barron and Hardwick have ascended the latter, but until their levels are to hand, it will be impossible to discuss the level relations of the mountain ranges to the big plain at their foot. At present Serbal, Eth Thebt, and Sabbagh must dispute the championship as being relatively the highest mountain in Sinai when considered from the eastern side only.

The ten mountains over 915 metres (the unascended peaks of Humr, Ethmid and Halefia are all probably over 1220 metres) bring out into clearer relief the difference between the relative heights of the two sides of the divide, and at the same time show clearly that the gradient of the valleys is very much steeper than the slope of the ranges. The first point is illustrated by the fact that nearly all of these are south of the transverse range, and the second that only one of these summits, Gebel Ethnarbi, is on the main chain. Mazea and Geraui, Um Ekhlis and Haimar are all on projecting spurs, while the Ferani range, which claims three of the remaining crests is within but a few kilometres of the sea.

The remaining mountain, Gebel Hormadjan, is higher above Wadi Isla than the crests dominating it to the west, thus being a further example of the second statement made above.

Of the 25 peaks above 610 metres, Abu Mesud and Fersh Sheikh el Arab, although nearly 2135 metres high, barely reach that level above the northern valleys, contrasting with Mazea and Geraui on the opposite side of Fera el Adhal, which though 305 metres lower, are both 915 metres above their base. Indeed of the 38 summits ascended north of the transverse watershed only seven exceed this limit, four of them belonging to the Ferani range and three being directly above the Nasb gorge. The remainder are either on the main watershed (Tellat Gimal, Sahara, Aad, etc.), hills closely associated with the main range as spurs (Um Taibekh, Maharrama, Genaui), peaks forming part of the Ferani range (Um Aleg, Lij, Et Wejera in fact all the summits of this range are between 770 metres and 915 metres above valley level), and the highest peaks of the schist region (Madsus). The granite ranges immediately west of the

schist region, and especially the great plateau of which Abu Mesud is the highest summit, are also over 610 metres above their southern valleys.

Leaving aside our own results, the Ordnance survey bears further evidence to the significance of the transverse line.

Only Zebir is near the 915-metre line, such important peaks as Um Shomer, Derawi, Er Rogha, Sinai, El Deir and the granite masses connected with them being barely above the 610 metre level.

Above or on the 457 metre level are the remaining important peaks of the northern plateau (Beidha and Hezaima), several of the hills of the eastern schist district, the striking white summit of a long ridge running parallel to Um Adowi on the southern side (Barakat), two twin hills (Themain and Ajuaf) conspicuous objects near the sea-coast of Nebk, the principal summits of the cluster of granite hills west of Sherm, the minor summits at the head of Wadi Letih, the granitic members of the transverse wall between Ferani and the sea, several of the isolated hills rising out of the centre of the Dahab amphitheatre and the plateau above the deep gorges of Wadi Nasb and Wadi Raib.

The levels lower than 457 metres may be said to include the limestone and sandstone hills of northern Sinai, and the granitic summits adjoining them, the dyke regions already mentioned, and the foothills rising above the coastal plain.

Speaking generally, the country north of the transverse divide tends to the plateau type, but is bounded by a range 610 metres (not exceeding 915 metres) on the west, and is deeply cut into big rifts of regular direction. Apart from isolated peaks and narrow ranges (Habshi, Um Allowi) its surface has been but little affected by denudation.

The country south of the transverse divide is, on the contrary, cut up into a complex of spurs and ranges, separated by valleys running more or less regularly in two directions, the higher summits being usually 610 metres to 1220 metres above valley level, while many of the lower ones exceed 762 metres.

Summary.

Before proceeding to further considerations, a summary of the main results may be here brought together:

1. The main mountain range from Sinai to Eth Thebt does not in general agree with the central watershed, the latter being usually a short distance to the *east* of it.

2. The main mountain line from Eth Thebt to Ras Mohammed seldom agrees with the central watershed, but the latter in the main lies to the *west* of it.

3. The main Sinai Peninsula mountain system consists of a series of long crests, (separated by high passes) trending north-east—south-west, and gradually lowering from 2592 metres in the north to sea-level at Ras Mohammed. The principal chain is bordered by a secondary longitudinal system, lower than the former in the northern half of the area, but together with the east-west spurs thrown off from it, rivalling it in the southern half. From Wadi Hebran to Ras Mohammed only two easy passes cross the chain, two others also being available for baggage camels.

4. East of Fersh Sheikh el Arab, a transverse system runs west and east to the Gulf of Akaba, the general level of the country to the north of it being higher than that to the south. The range is broken up into hill masses, gradually diminishing from 2135 metres at Fersh Sheikh El Arab to 457 metres at the Gulf of Akaba.

5. The *transverse watershed* is *identical* with the *transverse chain* at most of the important points.

6. The *transverse chain* is crossed by *five* passes (*two* available for baggage camels), which have this remarkable feature in common, viz., *that the valleys they connect form five roughly straight grooves, all parallel to one another and to the Gulf of Akaba, that is, in a direction somewhat west of south.*

7. A *coastal watershed*, broken at two points, runs close 1st to the Gulf of Akaba, and 2nd to the coastal plain, until it joins the spur of Haimar, running out from the main chain.

8. The *transverse chain* separates two districts:— a *northern*, still retaining much of its original plateau character, and having an *average* level of over 1220 metres, except where it is cut through by deep, narrow gorges; and a southern, cut up into a multitude of ranges and peaks, the valleys only reaching 915 metres at the bases of the main chain.

9. In consequence of the above, the northern mountains, though absolutely higher, are relatively lower above the valleys (rarely exceeding 610 metres) than the southern ones, which commonly rise from 610 metres to 1220 metres above the valleys at their base.

10. All the main eastern mountain ranges are included between the above watersheds, outside being either foothills, coastal-plain, or merely fringing coral-reef.

11. Within the hill-districts, the superior hardness of igneous dykes has produced a special form of country—*Dyke-Country*—in which the

harder rocks have given rise to parallel ridges separated by shallow valleys.

12. *Valleys.* — The three principal east-and-west trending valleys stand in sharp contrast to each other, thus:—

Wadi Nasb receives almost all its drainage from the north; Wadi Kyd drains the country both to north and south; Wadi Um Adowi drains the country mainly to the south of its course.

13. There are *six* north-and-south valleys, or rifts, each consisting of deep depressions bounded by steep-sided hills, running in a straight line, and only separated from one another by low easy passes. *Five of these valleys are roughly parallel to each other and to the Gulf of Akaba*, and where they meet the transverse valleys, in many instances the latter are deflected.

14. Three dominant valley-directions are noticeable; *south* of the transverse chain these run *south-east;* north of that chain, *north-east;* while the third system is that above-mentioned.

15. In contrast with these, on the western side of the main range, the predominant direction is north-west—south-east in the north of the peninsula, and south-west on its south-western side.

CHAPTER III.

DETAILED TOPOGRAPHY OF EASTERN SINAI.

In the desert area now under consideration the question of water supply and fuel is always one of prime importance, and upon these in part depends the nature of the route selected by the traveller. The visitor will have a choice of four principal roads by which to enter Eastern Sinai.

1. *Suez-Sinai road.*—The first, from Suez to Gebel Musa, will naturally be taken (either coming or going) by all those interested in the study of the Exodus, but need not be further dealt with here, as its various branches have been exhaustively discussed by the Ordnance Survey, and further examined by the Egyptian survey party under Mr. Barron. From the tomb of the Sheikh Salah in Wadi Sheikh near the Sinai Convent, a low and very easy passage leads into the plain of Senned, from which valleys branch out toward the east giving ready access to Dahab and Noweiba, on the Gulf of Akaba. Another easy

pass connects Wadi Sheikh with the plain of Rahabeh, at the head of Wadi Nasb.

2. *Tor—Wadi Hebran.*—A second road leads from Tor, the port of Sinai to the Convent through Wadi Hebran. Tor, in latitude 28° 13′ north, longitude 33° 37′ east, is a small town situated at the head of a bay protected on the west by the long point of Ras Tor, itself due to the presence of a coral-reef, and on the south-west by the Erg Riyah reef, with a passage on either side. The town consists of not more than a dozen large houses on the sea-front, these being mainly buildings connected with the Government or Quarantine service, and a mosque. Steamers have to anchor some little distance from the shore, stores, passengers, etc., being landed by feluccas and boats at a low pier of no great length. The population is of a mixed nature, the leading Government officials being Egyptians or Syrians, while the Quarantine service includes Greeks, Germans, and English in its ranks. The local trade is practically in the hands of two Greek shop-keepers who carry on a limited business with the inhabitants of the mountain districts. The monks of the Greek church connected with the Sinai Convent also have a large church and monastery in the town. Finally, the lower-class portion of the population has gained an unenviable notoriety for dishonesty, a reputation which was well maintained during our stay at Tor.

To the north-north-east behind the town rises the hill of Gebel Hammam Seyyidna Musa with its landward slope dipping steeply eastward to the broad plain lying between it and the mountains. To the north and east extends the plain of Qa'a backed by the varied peaks which rising abruptly from the stony desert form a mighty unbroken wall for many miles. Here and there some summits stand out in more prominent relief, Serbal, Zebir, Um Shomer and the ranges near Eth Thebt being conspicuous objects in the landscape. Near the town to the north is a group of palm-trees, and a little further on is a marked depression, El Wadi, which appears to be closely connected with Tor Bay and is a direct prolongation of the arm of the sea. This is practically one of the principal centres of the Bedawi in the peninsula, mud houses, each situated in a palm grove, being numerous. Here also are wells of good water, where the traveller by the Hebran route obtains the supply necessary to take him across the desert to the mountain valleys.

Beyond El Wadi the plain, at first broken up into ridges and shallow valleys, the latter often bounded by low light-coloured marly or gravel

cliffs, extends to the foot of Serbal. Although in part washed away, the road made by Abbas Pasha from Tor to Sinai is in many places still in good preservation, and can be clearly traced on both sides of the plain. As the mountain slopes are approached, the broad expanse is more and more cut up by steep-sided gullies, until suddenly a narrow cleft between two walls of red granite leads us from the dusty desert to the relatively luxuriant mountain valley of Hebran, with its running stream, its beautiful palm-groves, and vistas of steep mountain peaks or abrupt granite slopes. This is undoubtedly one of the most beautiful mountain valleys in Sinai, and from the pass at its head the steel-grey sides of Serbal and the bold dome of Madsus, tinted at sunsetwith deep shades of violet and purple, form a picture not easily forgotten. So many travellers have followed this route that its features have been thoroughly described, and as it also falls within the purview of the western party, we need not longer dwell on the tamarisk-groves of Solaf (in May exuding the sweet and glutinous manna), or the curious rifts of Watiya and Nagb Hawa, piercing the otherwise unbroken mountain barrier. At Watiya gorge, or a little before, this route unites with most of those from Suez.

3. *Tor—Ras Mohammed.*—The third route is one which is followed by those visiting Ras Mohammed or Sherm, and has been surveyed by Messrs. Barron and Hardwick. This route practically follows the sea-coast, or the plain of El Qa'a can be crossed and the central chain be skirted, until the easy pass of Hashubi is reached.

4. *Tor— Wadi Isla.*—The fourth route is the one by which we entered the mountain district, but before describing it the remarks on the neighbourhood of Tor may be completed. To the south-east and south of the town are three groves of palm-trees, one marking the quarantine-station, another further south, formerly marking the village of Qrum.* In the desert to the east, there are also a number of enclosures surrounded by strong wire netting, these being used as a camping ground for the pilgrims from Mecca, who are obliged to stay here for twelve days, and if any case of epidemic disease breaks out in the enclosure, those camped there have to recommence a quarantine of the same duration; when the cholera attacked Egypt in 1893 there were no less than 16000 to 17000 people thus imprisoned at one time.

Qa'a plain.—On leaving Tor, water having been obtained at Qrum, the great plain of El Qa'a has to be crossed before the mountains

* Quarantine buildings have now been built on the site of the village.

TYPICAL VALLEY OASIS IN WADI HEBRAN.

themselves are reached, its breadth between the town and the mouth of Wadi Isla being 22.5 kilometres. This great expanse, stretching away to the north-west and south-east as far as eye can reach, is topographically very uniform. At first near the sea-shore it is of raised beach character, shells of various modern Red Sea types being scattered over the surface, but further to the east the ground becomes more pebbly, consisting of quartz, felspar, etc., derived from the igneous rocks of the mountain district. An interesting feature, too, is the presence of a number of low sand-dunes rising from the plain, and probably never exceeding a metre in height, their crests having a north-east strike, while their steepest side faces south-east, these characters being due to the prevalence of the north-west wind. As the mountains are approached large boulders of granite, quartz-felsite, etc., are more and more numerous, and the plain becomes a series of low ridges separated by shallow depressions, which are the continuation of the ravines descending from the high ranges to the east. This region is one of the hottest in Sinai, the shade temperature on October 20th, 1898, being 97°.7 F. at 5 p.m., on the 21st, 84°.9 F. at 8 a.m., and on the 22nd, 100°.6 F. at 2 p.m. It will be readily understood that, under the circumstances, vegetation does not flourish, as there is absolutely no shade throughout the district, and consequently the normal temperature is far higher than that represented by the above figures. Nevertheless the *bowal* (*Zygophyllum album*), the well-known fleshy-leaved plant, is not uncommon, probably obtaining its water-supply from the moisture which sinks into the ground after the winter storms.

As the hills are approached, they are seen to possess one very striking feature, being striped in a remarkable manner by bands of red and dark-green colour, these being dykes of igneous rock, while the mountains themselves rise tier above tier, the magnificent rose-coloured precipices of Um Shomer being especially conspicuous. A few granitic ridges, owing their origin to the presence of the hard dykes, form the advance guard of the main hill-system, but with these exceptions, the boundary between the low land and high ground is very abrupt. Looked at from below the barrier seems impenetrable, and it is only when within a hundred metres of the opening that the ravine of Isla becomes visible, the valley having cut deeply into the gravels of the plain for some distance from the mouth of the gorge, before it becomes a shallow water-course like those previously referred to.

These raised plateaux of detrital material, terminating in abrupt cliffs at the edge of the valley are, like the dykes, amongst the most striking features of the peninsula, and are of great importance to the

traveller as camping-grounds in a district which, especially in winter time, is liable to sudden and destructive storms, the water, pent up between walls of solid rock, sweeping all before it in its wild rush. The anxiety of the sheikh of the party to avoid camping in the ravine itself was very noticeable, and the fear was justified when, a week later, a storm burst over the district, giving rise to one of the "seils" the name by which these torrents are known. The chief danger lies in their suddenness, and in the local character of the rainfall, so that a heavy rain may be falling in the higher valleys, while those camped below may be totally unaware of danger till the flood is on them. At the foot of the hills a little to the north of the valley opening are some ruined stone buildings of small size, while on the rocks at the entry of Wadi Isla are some drawings of ibex, etc.

Wadi Isla.—Wadi Isla throughout its whole length possesses characters suggestive rather of a rift than an erosion valley, being a steep cleft running without many flexures between hills which tower above it as bold precipices or steep slopes. Although it cannot be compared with the splendid gorges of the Alpine regions in Europe, Asia and America, owing to the comparative absence of vegetation and water, Wadi Isla possesses nevertheless a rugged beauty of its own, and the sharp contrast between the darker tinted gneisses which form the lower slopes, and the rose-red granite of the peaks of Um Shomer and Rimhan removes to some degree the sense of bareness and monotony which might otherwise be experienced. The occasional palm-groves scattered here and there possess a special charm from the fact that they are unexpected, and the small waterfall which is met with about halfway, trickling over ledges covered with moss and maiden-hair fern, and giving rise for a short distance to a stream which too soon loses itself in the dry pebbly soil, is fixed on the memory by its very rarity. From time to time the valley narrows, forming ravines bounded by steep walls of rock whose lower portions have been smoothed and polished by torrent-action. But rarely does it broaden out sufficiently to allow of the formation of gravel terraces, there being probably about three of these along its course. Tributary valleys are also very scarce, the principal one from the north being Wadi Emlaha, a wild boulder-strewn ravine coming through dark gneissose hills, behind which can be seen the red-coloured precipices of Gebel Rimhan. Further to the east Wadi Hormadjan enters from the south, rising in an amphitheatre surrounded by a semi-circle of mountains over 1000 metres high. The amphitheatre is connected with a lower valley by one of

the steep, rocky shoots (these smooth rocky slopes of 15 metres in height are in reality "dry waterfalls" during the greater part of the year), so characteristic of Sinai, and which form one of the most dangerous elements when climbing in the district, though fortunately the one here present can be easily rounded by following the talus slope. Gebel Hormadjan on the eastern side of the semi-circle overlooks Wadi Theman, which possesses one or two palm-groves, and is backed by the wild and jagged range of Safsaf, a southern prolongation from Eth Thebt.

Eth Themnin pass.—Wadi Theman is connected with Wadi Isla by a high pass, only traversible on foot, the upper part being somewhat broken. To the east of the pass the ridge rises in a rapid knife-edge, which terminates in Gebel Theman on the main Eth Thebt range, but an ascent of the latter from this side would be risky if not impossible. Time and increasing difficulty obliged the station to be placed lower than was advisable, although it was already over a thousand metres above the valley. It was, however, satisfactory to find that the guides were supplying the same names in most cases as those given on the Ordnance Survey map. Wadi Isla is formed by the confluence of two large valleys, Wadi Tarfa, descending from the north, and Wadi Eth Thebt, which, after a short northward course, bends sharply westward. The latter is bounded on the north and east by the ranges of the principal watershed, whose average height varies from 1525 to 1830 metres, while on the west the knife-edge of Theman-Eth Thebt rises in a series of steps to over 2435 metres. The valley at its upper end is formed of a number of broad feeders, descending steeply from the hills, but soon uniting in a wide expanse, where some Arabs are usually camped. One of these brought in a number of hyrax skulls, but the animal itself was not observed. Near its junction with Isla, Wadi Eth Thebt contains a very beautifully situated waterpool, hidden among boulders and a grove of palm trees, near by on a low rise being a few ancient monastic dwellings built in the rectangular form common to this type.

Humr-Eth Thebt pass.—One of the few passes connecting east and west Sinai runs from this valley into Wadi Humr. It is practicable for lightly-laden camels, but unsuitable, owing to the steepness of the rock-steps, for a caravan bearing heavy loads or having to deal with delicate instruments.

Two ascents of the central watershed were made in this district, both being of no serious difficulty, and under 1830 metres high. Tellat Gimal owes its long ridge to the presence of a felsite dyke, similar rock features also determining the structure of many of the neighbouring summits, while they can also be traced seaming the hills as bright-coloured bands for many kilometres.

Up to this point animal life had been but little in evidence although tracks of leopards and gazelle were numerous and two of the former animals had been seen by two of our Arabs when descending Hormadjan. Ibex, too, are evidently abundant in the central watershed, one, a female, coming close to the plane-table on Tellat Gimal, while subsequently Skill saw a fine male and several females on the slopes of Fersh Sheikh el Arab.

Wadi Tarfa.—This valley, which descends rapidly from the Tarfa pass, (Thilmet el Tarfa) is enclosed on both sides by hills which do not, however, compare in relative height with those bounding Isla and Eth Thebt, although the absolute height is not much less. Its ascent is not particularly easy for camels, there being a number of awkward rock-steps, having a smooth and slippery surface, but from the scenic point of view, the tamarisk bushes (tarfa) which give it its name lend a certain beauty to its lower portion ; while the upper part, at the foot of Fersh Sheikh El Arab, is very bare, being simply a stone-covered waste enclosed by a semi-circle of hills and seamed by deep nullahs draining the higher ranges.

Captain Palmer thus describes Wadi Tarfa : "From the pass begins the descent of a steep formidable *nagb*, by a winding and extremely rocky trail. A mile down, you come to a straggling line of *Tarfa*, and at intervals to pools and trickling water ; these continue for the next five miles, the glen throughout this distance being narrow and winding, the scenery sublime, the path up-and-down and stony, with several rocky steps and platforms ; there are also at some points passages between fallen rocks so narrow that camels with bulky loads have difficulty in scraping through."

Near its junction with Wadi Isla Wadi Tarfa receives the large tributary of Wadi Rimhan, descending abruptly from the north-west, a boulder-strewn groove such as is characteristic of this region. The Tarfa pass (over 1830 metres) is simply the lowest part of the bare range of hills which here forms the boundary between the Nasb and Isla drainage systems and rises to 2152 metres in the high summit of Fersh Sheikh El Arab, situated at the point where the central

JUNGLE SCENE IN WADI ISLA.

watershed bends sharply at right angles from an east-west to a north-south direction. The ascent of this mountain presents no great feature of interest, though the absolute barrenness is to a certain extent relieved by the presence of many bushes of *myrrh** (*Pyrethrum*), which is immediately noticeable owing to its strong aromatic smell, and *hamr* (*Anabasis setigera*), which was eagerly sought after by the Arabs for their camels. Numerous ibex were also seen on the sides.

Wadi Nasb.—On crossing the pass, an easy path leads into the broad plain of Rahabeh, which here forms the head of the Wadi Nasb, the most important valley of Eastern Sinai. The latter takes its rise in a high region lying between Um Shomer and Gebel Um Ja'assa, the southern summit of the Katherina plateau (Gebel Koli of Ordnance Survey), consisting of a number of low ridges owing their origin to the hard dykes which as red bands form their crests. From thence it descends in three or four principal arms, which themselves are broad and open, at the same time containing much vegetation, *kharit* (*Caroxylon fœtidum*) forming large bushes and occurring in abundance. Wadi Nasb at first runs between the foothills of the Fersh Sheikh El Arab and Abu Mesud ranges on the south, and those of Nakhala and Khasib on the north. The only important tributary from the north is the Wadi Rutig, which is the main road leading to the Sinai Convent from Rahabeh, but presents no special features of interest. Wadi Khasib is only a small valley, but contains pools from whence the expedition obtained their water when camped in the neighbourhood.

From the south enters the broad straight Wadi Wa'era which on the west is bounded by the spurs of Fersh Sheikh El Arab, and on the east by the lower range of Gebel El Feringhi or Gebel Hadid. At its head are a number of stone-circles, some of them double, e.g., almost 8-shaped, and also several rectangular single-chambered monastic buildings were noted. From this point an easy path leads across an undulating region of low granite hillocks to the plain in which Wadi Um Jiraf takes its rise, the latter thus separating the isolated hill-mass of Gebel Hadid from the high range of Abu Mesud, which rises rapidly above the level to over 600 metres. This locality has attracted a good deal of attention owing to the fact that the quartz-veins traversing the low country carry a considerable amount of good iron ore in the form of hæmatite and iron ochre, while a block of good magnetic iron ore was also obtained

* The Arabic names are here given for the convenience of those to whom the plants would be thus described by the Arabs.

on the road, but unfortunately not *in situ*. In Wadi Um Jiraf, Nabathean inscriptions have been found on some of the stone-circles which are crowded together in its upper portion, a clear proof that these curious structures either antedate or are contemporaneous with the Edomite occupation.* Abu Mesud presents no difficulty if ascended from its western side, and well repays the climb, it being over 2000 metres high, and commanding a view of the country in all directions. To the north-west and west the view is closed by the broad plateau of Katherina, and the rugged red peaks of Um Shomer; to the southward are the mountain wall of Eth Thebt, the twin summits of Ethmid, the long, thin crests of Halefia, and the truncated pyramid of Gebel Sabbagh; while to the east, the eye rests on a dark, confused mass of hills, mainly composed of schists contrasting strongly with the granite which surrounds them on every side, one of the most arid regions in the whole peninsula—barren ridges dominating sinuous gorges where only a scanty herbage finds a foot hold. Behind these is the broad deep blue line of the Gulf of Akaba, beyond which rise the purple hills of Midian. The mountain itself is the highest summit of a broad plateau over 1525 metres high, which terminates in abrupt precipices to the east and south, but slopes more gently towards Um Jiraf and Nasb. It is in fact, the most prominent member of the transverse divide already referred to, with the Fersh Sheikh El Arab and the high ground at the head of Wa'era forming the northern boundary to the remarkable basin of the Fera El Adhal which, enclosed in a semi-circle of mountainous barriers, only has one outlet, viz., to the east by the deep ravine of Wadi Kyd. The pass of Wa'era is therefore not only a break between two mountain masses, but the boundary between a high northern plateau and a deep depression, a steep path only traversible by lightly-laden camels leading down the rock-face. From the northern side of Abu Mesud a number of small valleys descend to join Wadi Nasb, the most interesting of these being Wadi Wadhih, which has a large group of stone-circles at its head.

While Abu Mesud (2110 metres), covered with dry vegetation to its very summit, is the culminating point of the plateau, other elevations rise from the same base, appearing as peaks of marked prominence when viewed from the valleys at their foot. The most notable of these are on the eastern side, Tha'albi, Abuzag, and the fine pink granite hill of Nakhara forming the edge of the mountain mass in that direction. It may be added in passing that the darker colour of Abu

* See also C. Wilson, "Ordnance Survey of Sinai," pp, 194-197 for fuller details.

Mesud and the flat character of the whole range is due to the presence of a felsite capping which has been partially removed by denudation. The presence of this rock has also played the most important part in determining the very flat summit of the broad Um Katherina, which rising over 2440 metres above the sea, is at once the highest and most conspicuous of all the Sinai hills, though lacking the rugged grandeur of its much-broken and deeply-carved granitic rival, the great peak of Um Shomer.

On the northern side of Wadi Nasb, the orographic character of the country undergoes a marked change, there being no longer broad, lofty table-lands, but hills lying in long lines trending normally in a direction parallel to the valley itself. Some distance to the north extends the ragged *sierra* which has Derawi (Um Allowi) and Er Rogha as its principal summits, while the lower hills extending between it and Nasb, at first sight from below so confused and barren, are seen on closer inspection from the higher summits to possess an extraordinary parallelism or to constitute a netted belt of ridges, the cause of these appearances being easily traceable to the presence of two systems of hard dykes crossing one another. There are, in addition, two hills in this direction which still show the flat-topped character, viz., Nakhala and the distant Habshi, both owing their form to the geological cause above-mentioned. Returning to the junctions of Um Jiraf and Nasb, and descending the latter valley, two peaks on the left hand or northern side at once attract attention, the one, Gebel Khasib or Ekhma, being a long crest which still has the dark colour due to the felsite capping, but possesses the character of a drawn-out ridge such as is marked in the elevations due to hard dykes. It is thus a transition between the two types above mentioned, but is completely overshadowed by the fine summit of Heza'ima, which rises abruptly as a single precipitous dome of almost Matterhorn-like aspect from amongst the surrounding low hills. The small valley of Wadi Heza'ima, which rises in the Khasib range to the west of this mountain, possesses all the usual features of the boulder-strewn Sinai gullies (hereafter termed boulder-valleys), but is bordered in its upper reaches by precipitous terraces of gravel. On the low rocks occurring at its junction with Nasb are a number of the *nawamis* or bee-hive stone dwellings which were only met with by us in this portion of Eastern Sinai. One of these, which was of small size was opened after first removing the flat granite slab which is always placed on the top of the main construction. Underneath was the skeleton of an ibex, which had probably crept through a small opening in the side of the building. Finally, on sweeping away the

rubble, a number of small cylindrical and ring-like beads were obtained, and a few pieces of very decomposed bone, tending to confirm the view previously expressed by Mr. Holland that these were most probably graves.

Another in very perfect condition lower down was also superficially examined, the central aperture at the top measuring 1 metre diameter having been also covered with a flat stone. The total diameter of the top was 4 ½ metres, being nearly a complete circle, while the low door which points west is 52 cent. wide and about 85 cent. high, the lintel being about 1 metre in breadth. As the building is on a slope, the lower wall is 1.8 metre high (composed of 7 layers of stone, the lowest consisting of great blocks of granite), while the southern is only 1·55 metre. There is gravel rubble on the top of the flattened wall. From another seen later on, it is evident that all these structures are of the form of truncated bee-hives but not complete, the opening left at the top being covered with a flat granite slab. Close to this spot is a huge granite boulder which might well have been used as a sacrificial stone, and is interesting in connection with a statement made by Dr. Grote (who has been constantly travelling in Sinai, and whom we met in the valley) pointing out the close connection of the word Nasb and the Arabic word for a stone altar, mazba.

After the junction of Wadi Heza'ima with Wadi Nasb, the latter hitherto wide but comparatively uninteresting begins to narrow, the granite foothills closing in on both sides and having a very striking appearance owing to the brightly-coloured red and dark-green dykes which seam the granite in close-set parallel lines. Capt. Palmer thus describes the locality: "The valley narrows from 200 or 250 yards to about as many feet, and then for more than two miles the road winds through one of the most curious and fantastic defiles in the country. The cliffs on either side are of no great height, but they are streaked from top to bottom with countless dykes, almost vertical and of bright varied colours—purple, pink, red, green and black, showing up in well-marked contrast against the dull yellowish-brown of the gneiss, or the sickly green tamarisks in the wadi bed. Some are a few inches, others ten or twelve feet in breadth, some a foot, others sixty feet apart; their numbers are extraordinary and all are very perfect, with hard, shining surfaces. The huge boulders, with smooth, dome-shaped tops and great hollows weathered in their under-sides, which lie piled one on another in wild confusion in the tributary glens of this valley, attract almost as much notice as the dykes. One such mass, of enormous size, at Um Zarabeh, is conspicuous above all the rest, it is a single rock, almost as large as the dome of St. Paul's, and even the smaller boulders

hereabouts are so large that you can walk with ease in the spaces underneath and between them as they rest one on another. The tamarisk grove, which extends for nearly three miles, is said to be, after the Tarfat el Gidarain, the most important in the country."

Just before we enter the deep and rock-bound gorge of Nasb, steep boulder-valleys enter it both from the north and south, that of Abuksheib winding round behind Heza'ima; while on the opposite side Wadi Beidha drains the range of that name. Wadi Threya, a tributary of Abuksheib, had, at the time of our visit, been the scene of a tragedy, a leopard having killed five camels the day before our arrival, but although Capt. Marriott, who was hunting ibex in the district, organized a special search, and the Survey party ascended the station of Gebel Nasb immediately above the spot from opposite sides, nothing was seen of this wily and destructive animal. The gorge itself runs between the spurs of two ranges of very different character, on the south being Gebel Beidha, which from its marked whiteness and massive outlines is one of the most striking of the mountains in this neighbourhood, in spite of its height being less than some of the surrounding crests. Its ascent from the west can be accomplished with much ease owing to the dykes of diabase running up the sides having been worn into grooves, which form natural roads. The summit is very flat, forming an excellent station (hamr, as on Fersh Sheikh el Arab, was abundant), and pools of water lay in hollows, being the result of the heavy storms which had been all round us since crossing the Tarfa pass. Indeed, this portion of our stay was attended with a certain amount of mild excitement as one night a terrific storm burst over the upland districts, and the roar of torrents could be heard every moment increasing in volume. The tents had to be hastily moved, and planted at an inconvenient angle on the slope, but while the higher valleys were swept out by "seils," very little water actually came down Nasb itself, well illustrating the local character of these heavy rainfalls. Here the first evidence was forthcoming of the great dread which the Sinai Arab feels for the dwellers on the opposite coast of the Gulf of Akaba, the sheikh of the expedition stating that he would on no account conduct us to the sea-shore. The only result of this refusal was his replacement a few days later by Ali Suliman, who has previously been favourably referred to.

The northern side of the gorge is bounded by a range running parallel to the general direction of the valley, in reality a long narrow crest due to a hard dyke, but rising into three summits, to which (adopting the Arabic system of naming the hill from the valley which drains it) the names of Nasb, Harban, and Khoseib have been given. Nasb gorge

stands out from among the wild ravines that characterize Sinai owing to the combination of vegetation with the sterner features of precipice and mountain-wall. Graceful tamarisks stand on both sides at its gate, and for several kilometres the path winds amidst a tangled jungle of palms, tamarisks, reeds, and rushes, while higher up some Arabs have made a garden of palms and dug wells, which seem to be placed dangerously in the centre of the main water-course. A few years ago a small stream trickled down the valley, but to-day it is only represented by a few pools, where purple-coloured dragon-flies skim the waters.

Tributary affluents are few and unimportant: From the north comes in the boulder-strewn groove of Harban (with stone buildings perched on the summit of a high terrace at its mouth), from the south the Seil el Beidha, draining from the hill of that name and terminating in one of those steep, smooth waterfall slopes, which so often mark the entry of the smaller feeders into the main valley. To the eastward, the hill becomes lower, and the great peak of Beidha is visible from base to summit.

Other wadis of note enter from the north, viz:—those of Khoseib and El Beagh, which like most of those draining from the hills are wide in their upper portion and narrow as they approach the main valley. There are also a few steep water-courses coming in from the south, viz:— Wadi Abu Sowera, a small boulder-valley bounded by fine cliffs; Krum Harbi, a gully with a pretty group of palms; and Wadi Bukka, having a fine granite basin near its entry into Nasb, which after rain contains a very pure water-supply. Finally, the broad upland expanse of Eggidi, lying at the eastern foot of Beidha, also enters Nasb by a narrow opening, and terminates in a precipitous fall, which renders it inaccessible to camels from this point.

The Nasb ravine is an excellent locality for sportsmen when water is scarce in the hills, as the ibex then come to drink at its water-pools. Capt. Marriott had shot nine of these animals between 18th October and November 6th, obtaining some very good heads.

The gorge broadens out at a point where two valleys enter it from the northern and southern sides respectively, this being the first example of the remarkable *cross-road* junctions of intersecting valleys so common in Eastern Sinai. To the north lies the important artery of Wadi Um Ghirat, which though a continuous depression is, as will be seen from the map, not a valley in the strict sense of the term, but in its lower portion a series of gravel terraces cut across by transverse water-partings. Um Ghirat is of importance also for the local circulation, as it forms an easy route to the plain of Es Senned through Wadi Senned and an alternative route to Dahab through the fine ravine of Wadi Gura.

Wadi Um Ghirat is separated from the Um Beagh drainage by a moderately high range, Gebel Matershat, and has at its junction with Nasb terraces of detrital materials 6 metres high, forming excellent camping-grounds. To the west of these comes in the small feeder of Um Kaimen, bounded by cliffs of gravel exceeding 12 metres in height. At first the road up the valley leads over several small plateaux of a similar nature, covered with rectangular stone buildings and circles, also crossing the drainage systems of Matershat and Kheirait (which cut across Um Ghirat obliquely), but afterwards enters a broader expanse, in which bushes of *retem* (a broom-like bush) and *abeitheran (Artemisia judaica)* are very common. Higher up, the wadi branches into two arms, the main one running to the west of a small dyke range, while to the east the broad Wadi Gasr receives tributaries from the high ground to the east, the most notable being Wadis El Mir and Ashara.

The characteristic feature of this portion of the country is the important part played by the hard dykes in giving rise to drawn-out ridges, running in two directions at right angles to each other. To this origin can be traced the form of most of the ranges in this neighbourhood, viz:—Kheirait, El Mir, Amu Jidid and Um Beda. On the other hand Gebel Serafat between Amu Jidid and Um Beda is in strong contrast to the other ranges, being composed of the characteristically rounded granite slopes.

A low and very easy passage (Haid Merzega) leads from Um Ghirat into Wadi Um Senned, which as a broad ravine bounded by granite cliffs seamed with many dykes, descends from the plain of El Senned to join Wadi Gura. Vegetation is here fairly abundant, consisting chiefly of *abeitheran* and *kebad* (*Zollikoferia*) as well as *aleigan*, a plant with an odoriferous sap.

On the pass of Haid Merzega was a leopard trap. The leopard can just crawl through an opening and immediately on seizing the bait at the same time pulls a string connected with a weight, usually a heavy stone, releasing the latter, which is balanced in such a manner that it falls through an opening, completely barring the exit.

The southern tributary of Nasb, Wadi Um Rachal, is chiefly noticeable for its straight character, the hills on both sides being comparatively low and of very variable structure. Just as in the case of Wadi Wa'era, this valley terminates at the edge of the transverse divide, on the southern side of which is a drop to Wadi Amlagh of several hundred metres. A zigzag path leads down the steep slope, but is readily available for heavily-laden camels. From here the interesting point was noted that the valley on the other side of Amlagh is in the same line as Um Rachal,

of patches of sandstone along this longitudinal valley, while at the head of Wadi Shelala the same rock now constitutes a barrier between the Nasb and Kyd drainages, forming a cliff over 100 metres high of brilliantly variegated or dazzling white colour. Wadi Shelala and the north-trending bend of Nasb are but parts of a long depression, itself continued to the north in the tributary of Um Raiyig, which enters the latter valley at the point where it again turns north-east. The remarkable character of this rift-valley has already been mentioned, as it runs at first between the dark range of Ferani on the east, and the rugged hills of Ashara on the west, and then for some distance northward between steep bounding walls of granite rising over 500 metres above the valley. From the bend Wadi Nasb is practically one continuous ravine except where tributaries meet it coming in from the north or south, the most important of which is the longitudinal fissure of Wadi Raib. After its junction with the latter, the bounding hills are less steep, and scattered along its course are low hills of friable white sandstone or gravel terraces, the most important of which is a rock over 100 metres high, rising abruptly in the angle formed by the junction of Nasb and Abuksheib.

Finally emerging from the hills, Wadi Nasb, now a shallow water-coursebounded by low cliffs 2 metres high, crosses the narrow peninsula of Dahab, a fringe of palm trees extending across its channel at the point where the valley enters the sea. On the gravel terrace above the valley are a number of ruined buildings of rectangular form.

While the valley itself thus bears witness to tectonic changes of great importance, an ascent of the scarps which bound it reveal the fact that they are but the edges of a granitic plateau which once extended continuously from the Ferani range to the edge of the Nubian sandstone escarpment, and still earlier was covered by the sandstone itself.

To-day it is grooved by valleys, cut through by deep rifts, worn into ridges and basins by differential weathering of hard dyke and soft granite, the result being the production of a number of mountain plateaux bounded by precipitous walls, and towering above wild gorges. Thus it is that Wadi Sa'al, starting its course in a ravine which caused Laborde astonishment by its Cyclopean grandeur, after for a time widening out in the sandstone region, becomes once again a deep cleft as it re-enters the granite, forming the narrow and winding valley of Wadi Hammam. Vegetation, too, is abundant, the most notable of the plants present being *rimth* (*Haloxylon Schweinfurthi*), which has never been collected by us south of the Nasb drainage, the aromatic *abeitheran*, large bushes of *kebad* (*Zollikoferia*), *gurdi* (*Ochradenus*) and *retem*. Here on a small

sandy terrace are a number of *ausedj*, a little further a grove of tamarisk forms a graceful picture under the shadow of the red granite cliff. The side-valleys terminate in many cases in sharp drops, or *seils*, broadening out above into wild plateaux where *theman* (*Peganum*) and *kebad* are present in great abundance. Ants, extending in long lines, traverse the valleys from side to side, partridges call from among the rocks, and hares evidently are of common occurrence, judging from the traces of their forms under the bushes. Finally, a small group of palms, only visible from the higher summits, is hidden away in the deepest part of the glen.

The plateau character is most marked on the eastern side of the hill-region lying between Wadis Um Raiyig and Ra'ib, the northern plateau above Abu Somra being capped by a number of flat-topped outliers of Nubian sandstone. Yet even here the differential weathering of the dykes gives rise to isolated summits, which generally receive their names from the valleys which drain their slopes. Five peaks are more striking than the others in this neighbourhood, viz:—Abu Somra and Gebel Ushtan, both dyke ridges, the twin hills of El Araish and Abu Thugutan, and the great yellow dome of El Rai'emshi, which at once strikes the eye from every point of vantage.

The country between Wadi Nasb and the Ferani range is again a high plateau ending in steep slopes over 300 metres above valley level, but is less deeply scored than the country previously described, the dykes, however, being very numerous. Most of the valleys rise in a broad expanse (generally known to the Arabs as a *fersh*), surrounded by hills of no great height, the most prominent of these being the Fersh El Hamra, situated at the northern foot of a high spur running from the Ferani range. The drainage of this region runs north, east and west, on the south being a mountain wall which rises steeply above the granitic country, formed by the cone of Abu Mesa'ud and the long crest of Um Shoka el Kebir. The principal mountain valleys, however, all trend northward and eastward, entering the Nasb gorge; they present the usual boulder-strewn character, but in addition the wadis of Sadagiya, Gurna and Um Hargel all contain palms. The latter receives its name from the abundance of the *hargel* bush (*Gomphocarpus fruticosus*) which was fruiting at the time, the greenish-yellow pear-shaped fruit being everywhere abundant. Most of these valleys, as well as the smaller water-courses, are characterized by the comparative richness of the vegetation, consisting mainly of *kebad* (*Zollikoferia*). They descend as broad gravelly channels between the ridges, but as they approach the edge of the scarp above Wadi Nasb narrow rapidly, finally terminating

in steep water-courses full of couloirs, often completely smoothed and polished. In fact, while the ascent of the hills was seldom difficult, the descent was not infrequently attended with a certain amount of risk if many of these dry waterfall beds had to be negociated. As is seen from an examination of the map, the whole granitic district is now broken up into a series of steep-sided table-lands, one of these, west of Gebel Gurna, being entirely cut off by three deep valleys from the remaining portion of the country.

After the junction of Nasb with Wadi Raib, the hills between the former valley and Um Shoka rise into three prominent peaks as described below, these being on the boundary of the felsitic and granitic rocks. Wadi Nasb is here characterized by the local abundance of *rimth* (*Haloxylon*) associated with bushes of *sommu* (*Cleome*), *harra* and *dafara* (*Iphiona*), a few seyal trees, and large senna plants. As has already been stated a very characteristic feature is the presence of white sandstone and gravel ridges in the valley, the most notable of these, over 100 metres high, filling the angle between Abuksheib and Nasb.

The three summits above-mentioned are the conical Um Shoka, the long north and south trending ridge of Hamra, and Jeraimda, which with its smooth granite slopes is very conspicuous from the seaward side, while in a little secluded valley on its northern flank nestles a small palm-grove of much beauty. These hills, ranging from 800 to 900 metres in height, separate the main Nasb drainage from that of the Abuksheib system, which receives its main feeders from the Ferani range.

Ferani range.—The latter is undoubtedly one of the finest mountain masses on the eastern side of the peninsula, the deep ravines by which it is furrowed being bounded by precipices seamed with *couloirs* of forbidding character, their floor being a confused heap of pebbles and boulders rolled down from the heights above. The nature of this range will be best understood from the fact that to map it required five successive ascents of or over 1000 metres.

The main chain of Ferani is remarkably flat at the summit, being apparently originally a plateau which has been cut off both to east and west by two of the rifts previously referred to, while to the south it is naturally bounded by the transverse valley of Sai'amin, and to the north terminates in the high rock-wall of Um Shoka El Kebir. The uniformity of the high plateau is best shown by reference to the height of the principal peaks, these being as follows (in metres): Um Aleg or

Halla (1,500), Ma'in (1,630), Zaraga (1,650), Ferani (1,520), Um Shoka El Kebir (1,390), and Lij (1,440). Um Aleg and Ma'in especially show the flat table-land character, the effect being very striking when, after a weary climb up boulder-gullies or round precipitous corners, one suddenly emerges on a smooth plain or undulating plateau, which on every side is bounded by deep ravines and precipices. Nor is vegetation by any means scarce, the summit of Um Aleg being quite white with the dried bushes of *hamr* (*Anabasis setigera*), which is one of the commonest of the hill plants in Sinai.

The northern portion of the range is drained by two deep mountain valleys, one of which, Um Athaga, is part of a longitudinal rift, while Um Harag cuts transversely across it. Um Athaga presents no special features of interest, being simply a fairly wide valley bordered by high ridges and connected with Wadi Lij by a low pass. Gebel Lij, the highest summit of the range to the west, is very steep-sided and is seamed by boulder-valleys, descending in a series of rock-steps which at times are difficult to climb. In descending the main drainage-line from the summit, a smooth shoot or *couloir*, over 30 metres in height, made further advance in that direction absolutely impossible, a tunnel worn under a boulder fortunately enabling the obstacle to be rounded with a less vertical drop. Notwithstanding these steep slopes, the summit itself is comparatively flat, though out of it rise boulder-strewn ridges of granite, forming fine precipices where they constitute the boundary of the scarp, and continuing for long distances as the edges of well-marked crests. It is also remarkable to find some stone-circles, one of them nearly 8-shaped, in a small hollow in the top of the mountain, in a place which from its isolation it seems impossible to imagine could have been chosen for purposes of habitation, or even burial. It seems far more probable that these represent the "high places" of the ancient peoples inhabiting the country, resembling as they do the circles to which M. Maspero assigns such an origin in his great work on the "Dawn of Civilisation." Here again *hamr* is the most widely distributed of the plants.

The valley of Um Harag, descending between the spurs of Zaraga, Ferani and Abuksheib, is far wilder than Um Athaga, and for part of its course, before it leaves the main mountain mass, forms a grand ravine, whose rocky walls rise abruptly above the boulder-strewn water-course. In its upper part it widens out, many bushes of *lassaf* (*Capparis spinosa*), with their large bright-green leaves, softening to some extent the bareness of the scene.

It is not surprising to find that leopards here have a congenial home,

one of these animals being seen by a bearer on the return from Zaraga, while in the morning their foot-prints were all round the camp, the leopards probably having been attracted thither by the presence of a dog, which kept up a continual howl all night.

In general, it may be said of the Ferani range that its summits consist of gently-undulating hills and valley-basins, terminating at the edges of precipitous slopes. Stone-circles are by no means limited to Lij, but are also present on the plateaux near the highest peak, i.e., Zaraga.

At the point where the united valleys of Abuksheib, Um Harag and Um Athaga issue from the main range, a well-marked gravel terrace with a perfectly flat surface forms a conspicuous object, while the valley is strewn with boulders of every shape and size, the camels having to find their way along the deeper water-courses.

Soon after leaving the mountains, Wadi Abuksheib passes from the dark felsite region into the lower granitic country, the dark-green ridges formed by the first-named being replaced by the light-coloured slopes characteristic of the granite areas. Two tributaries, both bearing the name of Wadi Ma'in, drain from a higher range to the west and the lower country to the east, the watershed being formed by some granite knolls. The long crest of Gebel Ma'in and Um Et Wejera is of some topographical interest, as it is drawn out parallel to the direction of the longitudinal rifts, and at the same time being formed of felsites above and granites at the base shows a contrast both in structure and colour. The ridge is seamed by numerous watercourses, there being also a few pools in one of these, where the valley is broken by a series of precipitous steps. While its western slopes descend steeply to Wadi Um Athaga, on the east there are some very marked gravel ridges, which seem to have been formed owing to the holding back of the detrital materials descending from the hills by dykes in the granite. Numerous stone-circles were met with in this neighbourhood.

Wadi Abuksheib receives another large tributary from the west, Wadi Um Shoka, formed by the union of three branches, two of which rise almost on the edge of the Nasb rift. One of these rises in the plateau basin of Fersh El Hamra and receives all the drainage of the mountain wall of Um Shoka El Kebir, while the other equally has its origin in a broad *fersh*, Fersh El Abuksheib, over a thousand metres above sea-level. Wadis Abuksheib and Um Shoka have their origin in this plateau, rapidly narrowing as they descend, and giving rise to wild and rocky gorges, where small smooth stretches, bounded by rock-walls and studded with bushes, are succeeded by steep rock-steps, or worse still,

smooth-sided, steep-angled *couloirs* down which the storm waters must form magnificent cascades after heavy rains.

Where Um Shoka broadens out, one of these mountain tributaries terminates in a rocky precipice some 6 metres high, having at its foot a band of conglomerate and a large hole, which is a splendid collecting-ground for water, though at the time of our visit it was almost dry. Were this depression filled, the water would be nearly two metres deep. Above the rocky step are many pools fringed by reeds where leopards, ibex and coneys are numerous, judging from the tracks. The wild fig or *lassaf* (*Capparis spinosa*) is extremely abundant in these granite gorges, and in the main wadi is a stone-circle near the head of the pass.

The mountain-walls bordering Um Shoka on the south are particularly wild and forbidding, the crests often being only thin knife-edges bounded by precipices on both sides. Here on one occasion, having lingered behind to examine an inlet of Nubian sandstone, I discovered one of our younger Arabs wandering among the cliffs, which here descend in a series of steps, and pathetically exclaiming that Skill and the others had been like ibex, and gone by a ridge where he dared not follow. The latter was certainly not devoid of difficulty, but as a rule we found that it was better to keep to the highest portion of the ridge whenever possible, as on the lower slopes steep rolling talus directly overhang cliffs where a fall would have serious results. While trying to find his way out, the Arab above-mentioned secured a young ibex, which unfortunately died two days later.

Before entering Nasb, Abuksheib receives the wide valley of Tellat Unsair, on both sides of which rise the narrow-crested granitic ridges of Um Isma and Tellat Unsair (635 and 510 metres respectively), wild fig (*lassaf*) being especially abundant in the gorges descending from the latter range. To the north of Um Shoka and Abuksheib, the mountains terminate in the prominent dome of Jeraimda, rising 833 metres above sea-level.

Gnai amphitheatre.—Between the Ferani range and Dahab lies a small region having a drainage system independent of those of the valleys of Nasb and Kyd, and owing its origin to the tectonic movements previously described. On the south it is bounded by the transverse divide, and on the west by the advance-guard of the Ferani range (El Wejera, etc.), on the north only a few low passes marking the separation from the Nasb system. The transverse divide at this point itself consists of a fine series of granitic hills, rising in Gebel Gnai

and Gebel Um Malaga to 1055 and 1215 metres respectively, the former especially forming a striking feature when seen from the central ranges owing to its smooth outlines and pink colour.

This district was first entered from the south, a fairly steep pass, the Sharafa, leading from Wadi Melhadge into Wadi Gnai, both these valleys being enclosed between steep ridges in a rift-like manner. Wadi Gnai is bounded on the west by the typical granitic ranges of Gnethel and Beidha; on the east the hills are lower and darker-coloured, but finally these are reduced to a thin strip behind which rises the imposing summit of Gnai. Wadi Gnai receives a few tributaries in its course, one of these, Wadi Gnethel, having some terraces at its head, on which are a number of stone-dwellings, five of them being of the rectangular type and the remainder stone-circles. One of these was still in excellent preservation, the stones being heaped up in such a manner as to form a narrow chamber, in which a man of medium size could lie extended, the opening also being of sufficient area to admit of entry.

In the main valley a noticeable feature is the abundance of the fleshy-leaved *ashara* (*Calotropis procera*), while among the minor plants *Zilla* is very abundant. In addition, a large *markh* (*Leptadenia*) bush, covered with hornets, and a bright dandelion-like composite, the *Numwerta hawa* of the natives, were noted. While the main valley is fairly rich in vegetation, the smaller tributaries are much more so, and in Wadi Hamra, near the foot of Gnai, among the large blocks which filled its course, were scattered bushes of *Artemisia*, *Zollikoferia* and *ghassah* (*Otostegia*) a few *lassaf*, and at the base of the mountain straggling bushes of *chibrim* (*Convolvulus hystrix*) not previously observed. Nor is vegetation restricted to the wadis, the shallow depression between the crests of Gebel Gnai being crowded with bushes of *jeradeh* (*Teucrium?*). *Seyal* trees are also frequently met with near the base of the mountain ranges. After a northward course of several kilometres Wadi Gnai bends sharply to the east, and becomes a wild and impassable ravine, Wadi Gnai El Rean (plentiful), so called from the presence of numerous water-pools, in contrast to Wadi Gnai El Atshan (thirsty), the other valley draining this limited region. These small pools are usually hidden among the side-valleys and are accompanied by palm-groves, whose bright-green tints, in sharp contrast to the red granite, form pictures of exceptional beauty.

The other valleys which drain into Wadi Gnai El Rean are small feeders descending from the granite ranges of Um Malaga and Ma'in, while the region lying between the hill amphitheatre and the sea is filled with low dyke ridges forming fairly conspicuous summits in Gebels

Tellat Sorar (745 metres) and Madjura (645 metres). These dykes are of two kinds, giving rise to corresponding differences of scenery, those of red felsite being noticeable at the head of Wadi Um Geyra, while between the summit of Madjura and the valley of Seyal Noma, ten dark bands seam the mountain side, and are continued across to the Um Malaga range. Altogether there are more than 25 principal dykes in a limited space, all parallel to one another, and some of them being over 30 metres wide. Crossing a low watershed, the drainage of Gnai el Atshan is entered by the valley of Seyal Noma, which receives its name from the abundance of *Acacia seyal*, this tree being associated with *Iphiona scabra*, *Zilla* and *Zollikoferia spinosa* as the chief vegetation, *Shouwia arabica* being also present. In the neighbouring valley of Tellat Sorar is a beautiful grove of seyal trees, there being more than forty close together. Wild ravines descend from the neighbouring hills, and it is no unusual occurrence to find remains of ibex killed by the leopards which appear to abound, though never seen. At the mouth of Wadi Gnai el Atshan the track suddenly opens out into a narrow plain only a few hundred metres broad, rapidly narrowing southward, while to the north it broadens out into the Dahab peninsula. To the south this expanse is bounded on the west by a knife-edge range rising in precipitous slopes, while the plain is dotted over with circular straggling bushes of bright green *araka* (*Salvadora persica*) and *gharqad* (*Nitraria retusa*). The latter at evening time are surrounded by hundreds of shells of *Dolium*, *Canarium*, etc., all apparently on the move, and producing a rustling sound. Close examination shows that the curious phenomenon is due to the presence of hermit-crabs, carrying about with them their borrowed homes, and come to feed on the sweet red berry which forms the fruit of this plant. A narrow band of vegetation fringes the shore of the Gulf of Akaba, consisting of stunted palms, rushes and a zygophyllum, in addition to the above-named bushes, while seaward stretches a narrow shelf of coral-reef over which the surf is continually breaking; where it stops abruptly, the water is of an intense blue colour, and it has been ascertained by sounding that the gulf itself is of great depth at this point. The sea-beach is composed of rounded pebbles, and it is evident that the Dahab peninsula is merely coral-reef flanking the granite hills, over which detrital material has been subsequently spread by streams, etc. Immediately beyond this beach is the living coral-reef, mainly consisting of madrepores and *Pocillipora*.

Approaching Dahab these features disappear, and opposite the

PLATE VII.

DYKE RIDGES OF MOGHTUT.

incurved promontory of the peninsula, sand-dunes line the shore, having been formed round the *Nitraria* bushes; these in turn are succeeded by a raised platform, covered with shells of the *Strombus fasciatus* zone. Still nearer the gulf the shells are very much polished, and specimens of the striking-looking, irregular sea-urchin *Lovenia* were present, this being the only spot where they have been noted in Eastern Sinai. Between the shore and the promontory above-mentioned is a shallow lagoon, covered with salt, through which rise knolls of black rock, apparently a limestone. At the extreme end of the point is a small lake, completely surrounded by raised beach, and bordered by similar black hackly rock, about ·03 metres thick, consisting almost entirely of oysters and igneous pebbles cemented together by a calcareous cement. Above this is a *Mytilus* bed, these shells being associated with the flattened petaloid sea-urchin *Lovenia;* finally at the cape itself, the beach above the sea is covered with shells of *Tridacna* and fragments of coral, the shore-line of the lagoon, but recently dry, being outlined by innumerable shells of a small *Cerithium* (*Pirenella*).

Dahab or Kara Bay has deeply indented the Dahab peninsula at its southern end, and there is fair anchorage in the deep water close to the shore. But the most characteristic feature of the peninsula is the presence of three large groves of palms situated close to the shore, the central one extending across the dry channel of Wadi Nasb; these date-palms belong to the Emzeina Arabs, and at the period of harvest all the owners assemble for the gathering of the fruit, bivouacking in booths made of straw, which apparently remain from year to year. Dahab is also notable for the presence of two important wells of ancient date, these being dug in the raised beach; of these the southern, that of Mishraba, is an inverted conical hole about 2 metres deep, lined with boulders and coral, while four thick palm-trees are disposed in rectangular fashion at the surface. The palm-grove near by is carefully tended and laid out in small plots, while in front extends the reef, a calcareous platform barely covered by the sea, in the interstices of which hundreds of starfish find a home. Here an old fisherman was met with engaged in spearing cuttle-fish, and apparently the sole inhabitant of the district at the time of our visit. There seems no reason why any number of wells should not be dug here, and palms planted along the whole border of the peninsula, there being some reason why these groves grow especially well close to the sea-shore.

A second small bay, that of Gahaza, breaks the regular outline of the eastern border of the peninsula, and is of interest because it exactly occupies the mouth of Wadi Nasb; as has been suggested elsewhere,

its presence may be due either to the unfavourable influence of the materials brought down from the hills by the rainstorms on the growth of the coral-reef, or to a secondary depression of small extent which has caused the sea to advance up the valley.

After the northern palm-grove is passed, the plain rapidly narrows until finally only a thin strip of low-lying land is present between the granitic foothills and the sea. It consists of four distinct raised beaches, the one with large shells (*Pteroceras*, etc.) being the most conspicuous, while that with *Strombus fasciatus*, etc., was only slightly developed. The abundance of large-sized sea-urchins is also a noticeable feature, these including most of the typical Erythræan forms, such as *Heterocentrotus*, *Phyllacanthus*, and *Brissus*. In some places a distinct calcareous boulder floor had been formed, which having been slightly raised above sea-level has given rise to a low undercut cliff, against which the sea is constantly breaking in sheets of foam. Aquaria full of the most varied life are everywhere abundant, in one of these pools is to be seen a clump of corals, in another chitons and barnacles abound, while at one spot a remarkable fish, with its pectoral fin broadened out, seemed to slide along the rocks. Unfortunately it disappeared in a water-swept fissure, rendering its capture impossible. Thick boulder gravels also rest on the slopes of the much-decomposed granitic foothills, and one of these cemented by calcareous material was noted lying on the summit of a diabase cliff 80 metres above sea-level. To the extreme north of the peninsula is a conspicuous white cliff, which on examination proved to be a raised reef, resting on a gravel derived from granite, and which near the point of junction is full of large boulders of the igneous rocks of the district.

The hill country at the back of the peninsula to the north of Wadi Nasb is similar to that on the south of the valley, its characteristics being briefly as follows:—A series of well-marked black ridges are produced by the dolerite and felsite dykes which run parallel to one another across the country. Between these are light-coloured steep slopes of granite, rendered very slippery by the presence of a thin layer of quartz, felspar, etc., due to the decomposition of the underlying rock. A noticeable feature is the almost cañon-like nature of the numerous small gorges, which seam the sides of the hills, owing their origin partly to the small amount of rainfall and partly to the denudation of basic veins, which are often seen to form the base of these ravines. The bottom of the gorge usually consists of long stretches of smooth, sandy valley (containing abundant vegetation), which suddenly terminate in abrupt rock-falls, from the base of which it

again resumes its previous character. If a diabase dyke be present, the steps are often easy of ascent, but if the rock be of a harder nature, it is necessary in most cases to retrace one's steps and mount the hill-face, so as to round the obstacle, which usually stretches across the ravine from wall to wall. The presence of these drops often rendered the return from the day's work somewhat exciting, as they present a considerable element of danger after nightfall.

While the main portion of Dahab peninsula is a plain, Wadi Dahab is bounded on both sides by a terrace of coarse gravel 2 metres high, on which (to the south) are a number of ruined buildings, most of them rectangular in form. A second terrace lies against the foothills, the boulders in which are much larger (over ·3 of a metre), and it is interesting to note that they are not only of coarse granite, such as would come from the neighbouring hills, but also include syenite and types of felsite which could only have been brought from the Ferani range. The vegetation mainly consists of *rimth* (*Haloxylon*) which is very abundant, and the grass *theman* (*Panicum turgidum*), while *dafara* (*Iphiona scabra*) is found more frequently up the side valleys in the hills themselves.

Region between coast-range and Gulf of Akaba.—It has already been remarked that a comparatively high range of hills forms a line of watershed which runs parallel with the gulf. Leaving the camp standing near Dahab, a rapid traverse was made along the shore-line to map in this region, which probably has not been previously visited, Holland having abandoned the attempt to do so. Immediately beyond the mouth of Wadi Gnai El Rean the plain narrows rapidly, the mountains descending to the water's edge in such a manner that only a narrow coral platform separates them from the sea. The hills themselves are of a threefold character, each type forming the front of the range in succession. 1. At first the light highly quartzose granite similar to that of the Gnai range is the principal member of the knife-edge ridges which extend nearly as far as Wadi Waira, these being succeeded in turn by 2. A darker group, the rocks in which show a distinct massive banding, and are mainly biotite-gneisses or hornblende-syenites. 3. At the mouth of Wadi Waira these are replaced by red and grey finely-banded gneisses. The granite forms sharp summits difficult of ascent near its junction with No. 2, and the dolerite dykes at this point are also very clearly marked.

To the southward a track suitable for lightly-laden camels runs over a raised reef resembling a most carefully prepared road of gneiss pebbles

cemented by calcareous material; where it faces the sea, forming a low undercut cliff, this raised reef alternates with stretches of raised beach strewn with large shells of *Tridacna*, *Strombus*, *Fasciolaria*, *Conus*, *Cypræa*, together with *Fungidæ* and corals of various descriptions. A noticeable feature is the heaping together of broken shells of a large *Trochus* or *Turbo*, possibly brought together by birds who may have selected these spots as their feeding-grounds. At one point the sea, at high tide or during storms, washes the foot of the hills themselves, where the camels have to be led over a difficult path, while further south beyond Wadi Um Tarfa the passage is absolutely barred.

Turning to the hills, it will be easily seen from the map that there are spurs projecting at right angles from the north-and-south-trending coastal-range, being separated from each other by narrow ravines often terminating towards the sea in precipitous drops such as have been previously mentioned.

Whether ascending Wadis Mowila, Sajerat or Um Ekhmoil, the same geological succession is observed, the now quartzose hornblende granite (with large sphene) being succeeded by grey or very broken red gneisses, which are often brightly coloured, the alternating green and red bands forcibly recalling the alternation of the felsite and dolerite dykes observed elsewhere. Although, taken as a whole, the ravines are sufficiently wild and forbidding, in places there are many seyal trees and some very pretty palm groves, notably in Wadi Sajerat, where in addition to the date-palms, pools of water, tamarisks and reeds with their bright-green tints, refresh the traveller who grows weary of the constant view of bare peak and stern desolation. The water unfortunately is brackish, a large amount of salt being deposited near the pools and on the diabase dykes in the neighbourhood. It is scarcely to be expected that this region, hidden behind rugged barriers, is likely to be frequently visited, but any traveller passing through Dahab would find this journey one of considerable interest. It will be noted that the Arabs have a name for every one of these out-of-the-way valleys, the palms in all cases belonging to definite groups of owners, who visit them at the date season to gather the fruit.

The coastal range itself was ascended from the western or Wadi Melhadge side, the most important mountain of the group being Gebel Abu Esherat (1125 metres), which is a species of minute Matterhorn, a sharp tooth of extremely precipitous character rising from the main crest. Looked at from below it seemed impossible to reach the summit, but following the rule adopted to attack every peak required as a station, and only to abandon it when every reasonable effort had been made,

(a) COAST RANGE (GULF OF AKABA).

(b) SHORES OF GULF OF AKABA.

the ascent proved of no exceptional difficulty, a fissure in the side of the precipice forming a natural path to the summit. At one point near the foot of the final ridge a boulder had been wedged in in an overhanging manner, forming an obstacle which did not prove formidable. The remaining characteristics of the coast-range will be treated under the Wadi Kyd section (see p. 72).

Wadi Kyd and its tributaries.—Wadi Kyd, as before stated, takes its rise in a basin-shaped depression, the Fera el Adhal, from which it is the only outlet, the valley forming a remarkably narrow ravine (from the side visited by the expedition apparently untraversible). Interesting as it would have been to have traced it to its commencement, the fact that the whole district had already been mapped from the summits commanding it, did not justify giving time to a point of detail, especially as Holland has already described the locality. The Fera el Adhal is bounded on all sides by the steep slopes of mountains, most of which rise at least 1000 metres above it, and owing to the abrupt character of the scarps, it can only be entered (apart from Wadi Kyd) by a narrow zigzag pass descending from the high ground behind Gebel Hadid. Wadi Kyd itself is reputed to be one of the most fertile spots in the southern end of the peninsula, and several of our Arabs acting as camel-men were owners of vines, palms, figs and nebk trees hidden away in this secluded glen. At the eastern end of the ravine a small running stream and many bushes of *lassaf* or wild fig give a touch of beauty to the scene, in sharp contrast to the boulder-strewn and desolate valley of Wady Umkheizen entering it from the south. Wadi Kyd now broadens out into a wide expanse containing numerous seyal trees, and is bounded on the north by the dark-green hills of Handar and Eth Themila and the pink ranges of Gazala, on the south being the foothills of Um Hashim. *Zilla* and *kebad* were abundant on the mountain sides, while in Wadi el Ghim, which joins Wadi Kyd from the north, *dafara* and *natesh* were common, the former being very green. Close to this junction there is a sharp line of demarcation between the granitic and schistose hills, while from the south enters one of the principal side branches, Wadi Um Gerat, itself formed by the union of the three important mountain valleys of Humr, Ethmid and Jendeli, which will next be considered.

Wadi Um Gerat.—Wadi Um Gerat follows the usual rule noted in these Sinai valleys, being bounded on both sides by the foothills of granitic ranges which rise in tier upon tier, both to the north and south, terminating in abrupt scarps or forbidding precipices, while the mountains are deeply scored with narrow and sinuous ravines filled with huge

boulders rolled down from the slopes above. The valley itself, on the contrary, has a smooth, even surface, and viewed from above looks like some calm and peaceful river, here and there scent-laden bushes of hargel (*Gomphocarpus fruticosus*) being a resting place for the praying mantis and other insects. But perhaps what will strike the traveller most forcibly is the remarkable banding of the gneissose rock which bounds this valley for the greater portion of its length, great masses of a granitoid gneiss alternating and interdigitating with dark mica- and hornblende-schists. The hills bounding Um Gerat consist of a series of wedge-like slopes, running both north-east and north-west, and at very variable angles to each other. At the southern bend the ordinary biotite-granite apparently overlies the schists, being often rich in mica, very friable and containing quartz veins, which have been much folded and fractured. Large dykes of a basic felsite also cut across one another on the western slopes.

Having camped on a marked gravel terrace at the foot of the boulder-valley of Abu Marua, Gebel Geraui (1695 metres), which rises 880 metres above the valley and is composed of schists and gneisses, was ascended from its southern side. It is seamed by quartz-felsite ridges which give rise to precipitous slopes where they meet the smaller gullies. It is needless to describe each ascent in detail, they usually begin with a scramble up some boulder-valley, then it may be, the rounding of some precipitous slope where a sharp rock step renders the gully of no further use. Usually the difficulties are most marked in the lower slopes, and though dangerous climbing in the mountaineer's acceptation of the term does not exist, it is nevertheless matter for thankfulness that no serious accidents occurred during the 150 odd ascents carried out in this portion of the peninsula.

The crests themselves owe their long drawn-out form to the presence of felsitic dykes which, as has been repeatedly stated, play so important a part in the structure of the peninsula. Of these the crests of Gebel Geraui, Mazea and Marua are more or less parallel, while Asafia is at an obtuse angle. The descent of this mountain was made by Wadi Geraui, a small mountain valley characterized by the presence of some fine waterpools. The broad valley of Wadi Jendeli entering Um Gerat from the south is distinguished by the abundance of its vegetation, *Retem*, *Zilla*, *Zollikoferia*, *Capparis* (wild fig), *Cleome*, *Lycium arabicum*, *Gomphocarpus*, *Artemisia*, *Hyoscyamus* and *Otostegia* being amongst the prevalent genera. At its southern end a pass, suitable for riding camels only, leads into Wadi Um Metir, and is thus a short cut into the Um Adowi area. One of the most notable scenic features in

this wadi is the abundance of dykes, both dioritic, quartz-felsitic and coarse granitic; having usually a north-east and south-west trend, though many cut each other at acute or even right angles. The acid types usually produce the sharpest ridges, but the dioritic masses are also very conspicuous.

Gebel Taibekh. — Already from Abu Mesud, a huge light-coloured granitic mass standing in front of the mountain wall of Halefia had been specially noticed, and its ascent provided one of the worst corners hitherto met with, the track leading for some metres on a ledge 15 metres above a ravine, with a foothold scarcely the width of a boot. The chief danger lay in the crumbling character of these granitic shelves and the entire absence of handhold in case they broke away. The mountain can be easily ascended from another side, but obviously in these great mountain masses it is impossible to say beforehand which of the ravines seaming the sides are likely to be most helpful. Taibekh, together with the still higher summit of Sahasia behind it, consists of biotite-granite or gneiss, this rock being traversed by two systems of dark dioritic veins nearly at right angles to one another, while in addition the gneiss is traversed by a coarse pegmatite.

Gebel Genaui. — On the opposite or eastern side of Wadi Jendeli is Gebel Genaui (1570 metres), the ascent of which is greatly facilitated by a path evidently well known to the Arabs, which leads finally on to a wide plateau at the foot of the main peak. Here Wadi Gasab takes its rise, and it is curious to find the ruins of many stone circles in this isolated region, whose presence was connected by our guide with a period when the rainfall had been much greater. This idea of a greater rainfall in past times seems to be a well-established tradition among the Sinai Arabs.

Ibex were very abundant on the mountain-side, seven being seen in the course of the ascent, including two fine males. The whole of Gebel Genaui and all the lower hills between it and Wadi Um Arat appear to be formed of biotite-gneiss readily decomposing, and traversed by veins of coarse red granite and diorite, the latter being parallel to the ridge running south from Genaui, while some of the more acid cross at an acute angle.

Wadi Humr. — Wadi Humr rises in the lowest part of the watershed between Gebels Humr and Tellat el Gimal and is bounded on both sides by ranges near or over 2000 metres high. Of these Asafia and Mazea

were ascended, the two summits being separated by a broad upland plateau, the Fersh Abu Kharub Um Asafia; a number of mountain plants were met with, including myrrh, hamr (*Anabasis setifera*), *Gypsophila* and *djahis*. This is the only locality where an umbellifer has been found during the expedition, one of the men bringing in a specimen of *kalth*, recognised by Dr. Schweinfurth as *Zozimia absinthifolia*. On Mazea are ridges of darker diorite veins which appear to have a general trend somewhat different from the conspicuous north-east and south-west ridges of deep red-coloured quartz-felsite already mentioned as being so conspicuous in the hills of Tarfa, Tellat Gimal, Geraui, etc. These become still more prominent in the Humr range, where they occur as huge black bands seaming the light granite or gneiss.

Wadi Ethmid. — Wadi Ethmid is one of the wildest spots in the whole peninsula, a deep ravine filled with terraces of huge boulders, and surrounded by mountains all exceeding 2000 metres in height, terminating in frowning cliffs or talus-slopes of the most forbidding description. It was fortunate for the purposes of the survey that it was not necessary to ascend Eth Thebt from this side, the southern mountain face being apparently a series of ledge-like precipices. Holland found the ascent long and dangerous owing to rolling stones, though he took the far easier road to the north; as in addition the shortness of the winter evening would have forced us to sleep out on the summit at temperatures below freezing-point, the ascent was not attempted, and as stated above, was not required by the work. The magnificent amphitheatre was mapped from the central ridge of Maharrama, itself 1833 metres high, and standing in front of Gebel Halefia, which is not much lower than Eth Thebt, and from a distance is always seen as a long ridge immediately south of that mountain. There is no break between the Humr and Sabbagh passes, without climbing which even in the higher sense might fairly be termed dangerous, but more from rolling stones than lack of points to hold on to. It is probable that these ranges are composed of red granite, and thus differ from those in front, which mainly consist of light biotite-granite or gneiss, and whose summits weather in rounded outlines.

Returning to the junction of Wadis Kyd and Um Gerat, the former now enters a region of sombre hills through which it passes as a bright streak, the granitic detritus giving it a reddish tinge forming an absolute contrast to its dark surroundings. This difference of tint is well shown where the two broad valleys of Ethmoi and Um Zerig join in from

the north and south respectively; standing on the rock ridge which projects forward from the main range at the junction with Ethmoi, the floor of the latter valley is seen to be of a dull-green colour, and only lines of stunted bushes follow the shallow drainages. Wadi Kyd, on the other hand, with its bright tints and comparatively plentiful vegetation, is a welcome sight after a long sojourn among the schistose hills. While speaking generally, the scenery in this schistose region is far tamer than in the granite and gneiss country, precipice and abrupt slopes are by no means absent, and Gebel Ethmoi has a formidable aspect when viewed from the valley, towering in fine castellated ridges above deep gullies seaming its sides. Here ibex seem to find an especially desirable home, as ten of them were seen at one time.

A little further to the east, Wadi Kyd receives Wadi Melhadge from the north, this valley being part of a drainage system having the most complicated twistings and windings. Not far from its junction with Wadi Kyd, the latter is joined by Wadi Madsus, which is itself formed by the union of Wadis Amlagh, Adakkar and Saiamin.

Wadi Amlagh. — Wadi Amlagh takes its rise in the low granite region between the Abu Mesud plateau and Gebel Beidha, Wadi Sheger entering it from the former range, and containing a number of good waterpools, similar reservoirs being present in the ravines descending from Gebel Tha'albi. A steep valley entering from the north leads up to an easy pass into Wadi Um Rachal, the level of which is far higher than that of Wadi Amlagh itself. On the southern side Wadi Khaiza debouches exactly opposite Um Rachal, and as has been stated previously, appears to be part of a rift system. These *cross-roads* are very familiar features in this portion of Sinai, and may be regarded as resulting from the intersection of two fracture-systems running almost at right angles to each other, the valleys in most cases being bounded by very abrupt mountain walls. Wadi Khaiza is no exception to this rule, the gentler slopes of the schistose Harasi and Hamra ranges being faced by the precipices of Tha'albi, Abuzag and Nakhara, which are only the edges of the Abu Mesud plateau. From this point Wadi Amlagh continues in an almost straight line eastward to the Wadi Madsus, only receiving unimportant tributaries, except where it crosses the Nasb-Um Raiyig rift, a broad valley joining it from the north, while a small watershed separates it from a drainage-line of similar nature on the south.

Wadi Adakkar. — This valley, which rises in the slopes of the hill of that name, is similar to Wadi Amlagh, and almost parallel to it.

From the north, when crossing the Nasb rift line, it receives the great Rahab feeder, while it is separated from the continuation of the depression by a low watershed. After passing between hills of gneiss, it enters the schistose region and soon joins Wadi Madsus. In the latter part of its course vegetation is almost entirely absent, but in the gneissose area, *harra* (*Diplotaxis harra*) is by no means uncommon.

Wadi Rahab. — The Wadi Rahab is distinguished from most of the valleys in this portion of the peninsula by its width and the abundance of its vegetation, such favourite camel-foods as *Crotalaria*, *Caroxylon* and *Zilla* being abundant. *Seyal* trees are also numerous in its upper reaches, especially where Wadi Sai'amin branches off from it and pierces the hill ranges. The latter present the most varied forms, owing to the superior resisting power of the innumerable dykes of quartz and syenite-felsites which seam the coarse diorite or finer grained biotite-granite of this region, while blocks of these harder rocks are strewn at the mouth of every small ravine which opens into the valley. Amongst these a spherulitic felsite and red porphyry were very conspicuous, and both were subsequently found *in situ* as dykes near the summit of Gebel Um Zaimer. As regards animal life, dragon-flies of large size were particularly abundant in Wadi Rahab.

A general examination of all the hills in this neighbourhood leads to but one conclusion, viz.,—that they are granitic mountains, now only overlaid with schists, having quite recently been released from their schistose covering. The true gneiss ranges are characterized by their steep and precipitous slopes with slightly rounded outlines, but with a green tinge absent from the granite; on the other hand the schists give rise to long slopes following the dip of the beds, whose smooth and polished surfaces glisten in the sunshine.

Wadi Sai'amin. — The upper part of Wadi Sai'amin is a very narrow ravine, whose existence would be difficult to explain without introducing tectonic changes. Here it is bordered by high vertical cliffs, which hide the peaks towering behind them.

Gebel Khalla. — One of these, Gebel Um Aleg or Khalla, was ascended and consisted on its lower slopes of a series of jagged ridges alternating with gullies filled with boulders, the former being due to the presence of dykes of syenite-felsite, etc. It had a curious effect, after wandering up precipice-lined water-courses and over boulder-strewn slopes, to suddenly emerge on the summit of a gently undulating

plateau, through which rise masses of the dark parent rock, this summit rock, which at the edge of the plateau gives rise to fine vertically-jointed precipices, being also felsitic in its nature, and forming the upper covering of the whole high mountain group to which Um Aleg belongs. A striking feature is the abundance of *hamr* (*Anabasis setigera*) at the highest points, looking almost snow-white by contrast with the deep brown-red colour of the rock itself. It was also remarkable to find a stone-circle in a depression of the plateau, this relic of human activity thus rivalling the circles of Haimar and Genaui in inaccessibility of position.

The Gebel Khalla range terminates in the peak of Gebel Sai'amin, which separates the ravine of that name from the wider valley of Wadi Lij, whose floor, formed of granite detritus, gives it a bright and cheerful appearance, while to the east the long ridge of Um Malaga is broken into the rounded bouldery summits so characteristic of granite hills, and is seamed by dark-blue dykes of dolerite. Vegetation is here abundant on the lower slopes, and in the upland hollows, the tall theman grass being most frequent near the base of the mountain where a few scattered seyal trees relieve the grim monotony of this otherwise desolate region. The descent from the ridge east of Um Malaga was made by Wadi Ethmiemat, where in a "fersh" or upland plateau, gravels were observed six metres thick, composed of granitic detritus and pieces of granite. These were distinctly, if roughly, stratified, and again lower down were found dipping in the same direction as the slope of the valley. Theman (*Peganum retusum*) and *kebad* (*Zollikoferia spinosa*) were both in great abundance, and water was present in five or six large pools lying in a small gorge cut out of the granite. This is evidently a favourite spot for ibex, and also the scene of many a tragedy, no less than tree pairs of horns showing that they had here fallen a prey to their active and wily enemy, the leopard. From the head of Lij is a bridle path communication with Wadi Um Athaga, while a similar one leads into Gnathel on the west, these being both suitable for riding camels.

To the west of Lij, Gebel Um Aleg rises in a frowning precipice, long talus of rock fragments descending from its lower slopes; while between it and the main valley are a series of pointed ridges due to quartz-felsite and microgranitic dykes. Wadis Lij, Sai'amin, Amlagh, and Adakkar, unite in the single sinuous gorge of Madsus, which is one of the most typical of the schistose hill-valleys. On both sides rise long, steep slopes of bedded micaceous schists glittering in the sun, and where they are traversed by dykes giving place to formidable precipices broken

through by deep gullies and torrent valleys. In the depths of the valley, only a few stunted bushes of *harra*, scattered in the stone-strewn ravine, maintain a precarious existence, while the dykes increasing eastwards add more and more to the complexity of the hill-form, and render caution in mountain ascending desirable.

Perhaps in our own case the impression was deepened by the atmospheric conditions, storm-clouds hanging heavily on the mountain summits, the whole culminating in a grand thunderstorm, where all the fury of the elements seemed to be let loose. The continual flash of lightning, the roll of the thunder, the roar of torrents, and the splash of the storm-rain on the bare rock combined to form a picture of chaotic grandeur such as is seldom witnessed, and remains indelibly fixed on the tablets of the memory. Long after the turmoil had ceased, a torrent rolling its turbid waters down Wadi Kyd alone broke the silence.

The upper part of Wadi Melhadge is, like Madsus, wild and inhospitable, bounded on all sides by bare hills, from whose flanks descend gullies strewn with enormous boulders. Conspicuous among these is Wadi Um Esherat, where the rock masses, rolled from the slopes above, recall similar confused boulder wastes in the Alpine regions. Hill-summits, only distinguishable by their form and tints, rise on either hand, to the east the sharp tooth of the Tower, further south the yellow-tinted Um Zeireh, connected to the red-dyked summit of Ras Achmar by a long crest.

To the east of the Tower hill, the granite forms hogsback ridges at a much lower level. Still further south, the ranges of the central watershed (Gebel Arabi) trend directly east and west, the dark schists composing them being entirely obscured by the abundance of the dykes which seam them on every hand. The sides of the mountains are steep and covered with talus of readily-rolling materials, while the crests are normally knife-edged ridges due to the dykes; so that the ascents of these comparatively low hills were often exhausting and difficult.

Throughout the whole region desolation reigns supreme, *Iphiona scabra* being the only plant in the wadis, and water alone being present after heavy rains. The most conspicuous of these east-west ranges is the Arabi or Ghrabi chain which rises into three main summits, the central one being most noticeable on account of its precipitous character. The western end of the range sloping towards the Gulf of Akaba is composed of granite, the change in the rock-structure being marked by a drop in the general level.

On the eastern side of Wadi Melhadge, the schistose country is much less broken by sharp ridges, the long shiny slopes forming a great

amphitheatre bending away from the valley, and rising to its highest levels in the summits of Madsus, Akhmara, Ethmemia, Um Sailem and Hamra.

After its junction with Wadi Melhadge, Wadi Kyd is deflected sharply southward, and shortly after is joined by two valleys from the east and west respectively. Both of these bear the name of Wadi Gebila, and are bounded by steep-sided schistose ranges, whose characters are similar to those already described. The eastern Gebila valley is of some importance, it being the first point south of Dahab by which a camel expedition can cross to the Gulf of Akaba. The pass presents no difficulties and the descent seaward is between slopes of light-tinted granite. In all respects the contrast was striking, behind us the dark hills, the stillness, the absence of life; in front the surging sea, teeming with tropical life, and stirred into continual motion by the fresh north-east breeze. In general the plain which lies between the hills and the gulf is a plateau which has been seamed by the winter torrents till it now descends in long tongues seaward, widening rapidly to the south, but to the north terminating abruptly where the rocky slopes of Arabi rise sheer from the waters. A prominent feature on the shore is the low white cliff or ridge of Ras Atantur, an old raised coral reef (20 metres high) on whose eastern flank is a storm-beach strewn with shells of *Tridacna*, *Conus*, *Natica*, etc.

Returning now to the junction of Wadis Kyd and Gebila, the valley continues its course southward, the bounding hills becoming ever sterner, darker, and wilder, until suddenly at its junction with Wadi El Beda, the higher ranges cease abruptly, and only low foothills lie between it, the sea, and the western mountain ranges. At the mouth of the ravine a gravel terrace extends almost from side to side, and soon the dark schist scenery is replaced by the rounded, smooth, light-tinted, granite country which fills the space between Wadis Kyd, Um Adowi, and Merari. The change is also marked by the sudden increase in vegetation, *arta* (*Calligonum comosum*) bushes, in March green with fresh young shoots, following the watercourses, and attracting the gazelle from all quarters. Fifteen of these graceful animals were seen at one time, browsing peacefully and all unconscious of danger. Between the shrubs of *arta* the *'arra* (*Aerua javanica*) lifts its white-tufted woolly head, and the camels as they passed pressed down the aromatic *betheran* (*Artemisia judiaca*). Large bushes of *gurdi* (*Ochradenus baccatus*) carried minute yellow flowers on long thin stalks, and rounded clumps of prickly *sommu* (probably *Cleome droserifolia*) filled the interspaces.

It may be owing to the proximity of this fertile spot that the neighbouring granite hills contain the largest hyæna colony in that part of the country. A well-marked track leads up wide, sandy valleys and across low hills of granite to the Darb el Dhuba, where large granite boulders lie in a confused mass. Underneath these the hyænas have burrowed, taking advantage of the shady spaces and hollows under and between the superincumbent rocks; in and around the openings are strewn the remains of many a raid, remains of camel-skulls and jaws, bones and horns of ibex and sheep, hair of ibex, and even a soda water bottle, the end broken off, but with cork intact, and pieces of iron. But though it was the full glare of midday, the animals themselves were nowhere to be seen, probably having scented danger long before we made our appearance. At this spot there are some ten dens. The Bedawi have a tradition that if an Egyptian fellah comes near a hyæna, the latter attacks and eats him, the fellah having a special scent. This may possibly have been of recent origin, and invented for the benefit of the Egyptian servant who accompanied our expedition.

On receiving Wadi Merari, Wadi Kyd bends sharply east, and leaving the granite ridge of Ras Berga on the south and some low foothills on the north, crosses the plain to the sea as a shallow water-course. The only noticeable features before it enters the plain are three well-marked flat terraces, two on the right flank of the valley, and one on the left at the corner where it enters the plain. Over the latter are scattered circular bushes of *arrak* (*Salvadora*) while dark-green groves of *shora* (*Avicennia*) fill some of the shallow sea-bays, prickly *Fagonias* being also common. On the other hand the valleys of the granitic regions of Um Berga are brightened by numerous seyal trees and bushes of *Zollikoferia.*

One important tributary system of Wadi Kyd remains to be considered, viz:—the one opening by Wadi Um Beda, which receives Wadis Tema, Genaui, and Yahamed. Wadi Tema itself is a valley of no great length forming for a short distance the boundary of the granite and schists, on the west being overlooked by a steep and many-crested granite range, while on the east rises Gebel Zegir, with softer outlines but sharp dip to the wadi. It was in this valley that some of the interesting "mictosites" subsequently described were best displayed.

Wadi Genaui enters from the west, itself receiving Wadi Gasab, which has a winding course from the Fersh El Gasab at the foot of Gebel Genaui, (see p. 67) and seen from above appears to be in the main a narrow ravine. The space between the three valleys is occupied by a confused mass of low hills extending to the plain, out of which

PLATE IX.

LOWER END OF WADI KYD, LOOKING WEST.

rise a few more conspicuous summits. Wadi Yahamed, descending from the central mountain chain is of more importance, and reversing the order usually followed in this memoir, will be traced from mouth to origin. Wadi Um Beda itself is still in the schists, but after passing into Wadi Yahamed the granite region is once more entered. This valley in its lower portion is broad and sandy, but suddenly narrows at the gates of Yahamed (Ergain) to a fine ravine, bounded on both sides by precipitous walls, while the central portion is studded with bushes and seyal trees to an unusual extent. This ravine opens out into a wide upland, bounded to the west by the rugged crests of the central range, and in other directions by spurs of considerable height. Only to the north is there a break in the hills, forming a camel-pass into Wadi Jendeli.

When camped one evening near the gates of Yahamed, a great cloud was seen to settle over the massif of Sabbagh, and when the pall lifted next morning, the mountain was covered with a sheet of glittering snow, no doubt to the great astonishment of the Qena Arabs, who though displaying no surprise acknowledged they had never seen snow before. The next day, camp was planted as high as possible in the boulder-valley of Sabbagh, the mountains round looking cold and grey, with snow lying thick in every crevice, and forcibly recalling the ranges to the east of the Furka pass.

On the 31st December, the party divided, Skill and one of the Arabs ascending by the dangerous-looking couloirs on the precipitous face, while the remainder, following the boulder-valley, approached the summit from the rear. The climb of a little over 1000 metres presented no special difficulties except such as were due to the circumstances of the moment, and the fact that the thistle-like *hashir* has a special preference for spots where hand-hold is most necessary, and its presence therefore specially objectionable. The Arabs suffered somewhat severely from frost-bite, whose effects lasted several days, and one here laid the foundations for an attack of nightblindness, which developed two months later, probably aided by the effect of the sun's rays constantly reflecting from rock surfaces. This awkward illness is very prevalent in Sinai, and in the case of the Arab above-mentioned began quite suddenly. The writer was descending from Gebel Madsus by a boulder gorge, and was a little ahead of the two Arab carriers, who had stopped to drink at an unexpected waterpool. Night was rapidly approaching, and as these ravines are very dangerous after sunset unless the moon be up, it was not advisable for the members of the party to lose touch of each other. On this occasion the light was fast

waning, when it became clear from the length of time that something must have happened, and re-ascending the gully, I found one of the Arabs was apparently stone-blind, and it was only with much difficulty that his companion had succeeded in bringing him out of the worst passages. Happily the sheikh, having grown anxious at our non-appearance, had ridden up the main valley on his camel, and was able to give the sufferer a lift to the camp, still some kilometres distant. It was a great relief next morning to find the true state of the case, but it was afterwards always necessary to send this Arab (who was one of the best climbers and carriers) on ahead, if there were any likelihood of being in the hills after night-fall.

The water-supply of the upper Yahamed valley is good, and consequently there is always here a small community of Arabs, who spreading their striped tents at the foot of the mountains find pasture for their camels, sheep, and goats, in the comparatively fertile uplands. South of the gates of Yahamed there is a break in the hills, an easy path which gives ready access to the third great drainage system of East Sinai, Wadi Um Adowi.

Wadi Um Adowi.—This wadi runs in an almost straight east-and-west line from the Adowi pass to Nebk. The upper part of the valley is a wide plain, above which rises the bold crest of Um Adowi, 1000 metres high, while at its feet sheep and goats graze tranquilly among the seyal trees.

The ascent of Um Adowi, which looks at first sight a serious undertaking, is in reality a mere climb, owing to the presence of the dolerite dykes which seam its sides. These trending at acute angles to the main ridge gradually ascend, now dipping into a boulder-gully, now rising on the sides of a precipitous slope, but always forming a natural road or series of steps slightly let in to the granite they traverse. Near the summit a broad boulder-gully crosses the dykes, and enables them to be abandoned; in it ausedj (*Nitraria*), kebad, zafara el gebel (*Iphiona*), ghassa (*Otostegia*) and getheeb are met with in great abundance, whereas in Sabbagh only myrrh (probably *Pyrethrum*) and hashir (*Echinops*) were observed. The highest point is a rounded knob of granite just large enough to hold the plane-table and observer, the precipice descending steeply from it on three sides.

In descending, Skill came across some fine pools of water, with maiden-hair fern (*Adiantum*) growing in abundance.

The upland valley at the foot of Um Adowi, and especially the gravel terraces which fringe its base, have been the scenes of strange

PLATE X.

STONE CIRCLES AT FOOT OF ADOWI.

changes in past ages. On the terrace of Um Jeraif the stone-circle builder has been active, viewed from above it being apparently covered with a series of such circles, composed of an outer ring, and having a heap of stones in the centre. One of the larger was measured, its diameter being about 15 metres. The outer ring consisted of four tiers of stone blocks, 1·05 metres maximum height, the width of the wall being 1·8 metres, and the breadth of space between it and the central heap 3·6 metres. The diameter of the latter was 3·6 metres, and the western side of the wall 2·2 metres thick, it being somewhat lower than that on the east. The average diameter may be taken as 6 metres. Nothing remains to give a clue to the race who erected these strange constructions, and their memory had already long been hidden in the mists of antiquity, when a solitary monk built a solid stone rectangle at the foot of Um Adowi, its exit at so low a level that it is impossible to enter without stooping. He and his too have passed away, yet to-day the valley still exerts its attraction, the striped tent of the Arab being spread under the wind-sheltered slopes of the terraces, while women in long face-veils draw water from the mountain pools, and flocks of black goats crop the scanty herbage and young leaves of the seyal.

Long before this region had been reached, a white serrated ridge had been seen in the distance, rising ghost-like in the evening light. From the open plain Wadi Um Adowi narrowing, now skirted the foot of this hill, Gebel Barakat, a tumbled ruin of granite boulders seamed by the ever-present veins. On the north rise similar bare hills, the heights of Battagh and Somma, where great dykes stand out in long ridges from the crumbling granite slopes. The whole scene is a vivid record of the action of the denuding agents, here the long knife-edge of Barakat, its sides strewn with the giant boulders of its wreckage, behind it to the south an apparently confused mass of hills and valleys, out of which rise isolated domes, remnants of a granite mass that once was, while long red ridges trending in lines across the country owe their existence to the harder dykes which form their core. A little beyond Gebel Barakat, the great feeder of Letih enters Adowi from the south, the junction being overlooked from the east by the two sentinels of Themain and Ajuaf, which rising from among relatively low hills, have an imposing aspect.

On the 9th of January, a cold clear morning (2°·0 C. at 6.30 a.m.) the hill of Hamra was ascended, and to the north-west rose the white dome of Zebir, clothed in a mantle of newly-fallen snow. From here fine terraces were seen in the valleys to the north-west and south-west,

while at its base Wadi Um Adowi was filled with low bushes of dafara (*Iphiona scabra*). The next station, Gebel Um Uwerid, involved a somewhat difficult scramble, owing to the very rounded nature of the granite summit, but commanded a fine view of Nebk and the Gulf of Akaba, the former being a beautiful palm-grove extending across the shallow waterway by which Um Adowi enters the gulf. The position of the palm-groves and wells is a feature worth noting, as it suggests that the water which has sunk in the gravels of the valleys is ponded back at its contact with the gulf. If this be so, a good water-supply may always be looked for at the contact of a large valley and the sea, unless the water has in its passage passed through rocks contaminated with salt. There seems no reason, for instance, why a good palm-grove should not be formed at the mouth of Wadi Kyd which shares with Um Adowi the distinction of being one of only two passages through the central watershed.

It has already been stated (p. 27) that Um Adowi receives the whole of its drainage from the south (with insignificant exceptions) the valley of Letih acting as the principal channel. This valley, which hitherto has been regarded as breaking through directly to the gulf is, as has been seen, deflected northward by low hills and a gravel ridge. Wadi Letih rises in a region of wild hills, among which Ethnarbi and Sahara take the first rank. Immediately at its head are two passes, that of Tehih being suitable for riding camels, while the one into Wadi Budr is only a sheep-track.

These mountains display all the characteristic features already so familiar in Sinai. A great dyke of dolerite, 40 metres broad, forms a natural road for a long distance along the summit of Ethnarbi, while others, crossing one another at sharp angles, present X-shaped figures in the precipitous slopes bounding the valley. Steep boulder-gullies descend from the surrounding hills, often terminating in "seils" (or dry waterfall beds) where now and then a rare pool of water fills some secluded and shaded granite basin. In the smooth stretches and among the boulders plant life grows in abundance, here bushes of *Zollikoferia* and scented *Artemisia*, there shrubs of *Nitraria*, *Otostegia* (with its white-lipped flowers), the dark masses of the aneb-ed-dib (*Solanum nigrum*), *Shouwia arabica* and the cruciferous *Harra*. Large terraces fill the interspaces between the hills, forming safe and suitable camping-grounds, while high in the centre of the ranges are many wide "fersh," where the ibex wander undisturbed, and are consequently present in somewhat large numbers.

The Arabs would not eat one of these animals shot here, because it had not had its throat cut immediately after death.

These upland valleys are also the home of many coneys, whose peculiar tracks are traceable in the soft gravels, and hares are also not entirely absent.

On Um Zeynig it was possible to test the magnetic effect of the spheroidal diabase dykes traversing the mountain side, the compass being deflected 10 degrees, while a thick dyke of dolerite was also found to have magnetic attraction.

Gebels Sahara and Ethnarbi command fine views of the whole southern stretch of Sinai, their western faces descending steeply to the plain of El Qa'a which, except for some low dyke foothills near the central range, extends unbroken to the deep blue waters of the Red Sea, beyond whose western shore rise the distant purple hills of the African wilderness. It was curious at times to watch great ocean liners passing to and fro, the sense of isolation being deepened by this apparent proximity to one of the greatest of ocean waterways.

Gebel Sahara commands a fine view of the complex scene in Eastern Sinai, the importance of the dykes which of huge size seam the mountain itself being very marked. The long ridge of Ethnarbi is seen to be formed by a red dyke, Barakat is crossed by four bands, two blue (dolerite) and two red (felsite), while Somma and Battach are lined with similar bands, whose normal direction of trend is to the north-east.

The sudden character of the rainstorms was well illustrated on February 11th. It had been proposed to ascend Gebel Hamra, but on the way the plan was changed, and Mobera, a commanding hill on the northern side of the valley selected as the station. The morning was clear and still, but soon after reaching the summit, clouds collected on the opposite slope of Ḥamra, the storm bursting over the latter at noon with terrific violence. In a few moments the whole mountain-side was foaming with innumerable cascades while the rocks rolling down the boulder-valleys descended with the roar of an avalanche. The front of the storm passed some 300 yards from our station, yet beyond some hail, a few showers, and heavy clouding, its effects were unfelt, and the day closed with a beautifully clear, still evening.

A cascade descending from the hill and forming a small stream was quickly swallowed up in the gravel of the valley, and masses of micaceous sand bound together where the torrents had passed were the only evidences of the storm yet remaining. A notable feature in the valleys are the streaks of black sand, which from their form and non-magnetic properties are in the main crystals of hornblende. A particularly fine seyal tree is also one of the features of the upper portion of Wadi Letih and formed a useful valley station.

The mountain portion of Wadi Letih terminates at the Gates of Letih (Ergayn Letih) where it issues as a broad valley (comparatively rich in vegetation) into one of the most characteristic of the Sinai dyke regions. To the south Gebel Haimar still extends its frowning buttresses for some distance, of which the two low granite hills of Khanashir and Mabledge might be regarded as advanced foothills were they geologically similar. Between them and Gebel Barakat is low granite country of peculiar character, the granite having undergone remarkable weathering into domes and pillars (see plate XI) or broad-backed rounded hills. Still more striking from the topographical point of view are the long ridges produced by the north-east trending dykes, these rising as low splintery crests, separated by shallow sandy valleys. Plant life is comparatively abundant in this region (see p. 96). The northward deflection of Wadi Letih by a gravel ridge has already been mentioned (see p. 27) and soon after it enters Wadi Um Adowi as a broad valley rich in *Artemisia* and dry *Zilla*. The valleys of the granite region on the west of Letih either fall into this valley, or when draining north-eastward, into Wadi Mandar, which skirting the southern foot of Barakat joins Letih near its junction with Um Adowi. To the east, the scene is wilder and more desolate; the twin peaks of Themain and Ajuaf rising stern and precipitous above the bare gravelly valley of Na'aj, where bushes of blue-green *Iphiona* and dry *Zilla* alone relieve its desolation. As stations these hills are splendid, commanding as they do the whole of the low country north, south, east to the Gulf of Akaba, and west, but otherwise remain in the memory only as a wild scene of bare rock and deep ravine.

Wadi Aad.—Of the remaining valleys of Southern Sinai, Wadi Aad is undoubtedly the most interesting and important. Commencing as an upland plain, it is dominated on the west by three important summits—Aad el Gharbi, Aad, and Haimar, the first two members of the central range, while the latter is one of its most important spurs. A low pass at the head of the valley separates Aad el Gharbi from the lower hills of Madsus and Awaja to the east, there being also a noticeable contrast in the form and tint of the hills on the two sides of Wadi Aad. The dark hill-ranges to the east are mainly hornblende granite, while a biotite-granite traversed by red felsite and dark dolerite dykes produces the characteristic rounded outlines of Aad el Gharbi. The wadis descending from Aad el Gharbi are also steeper than on the Madsus side, this also being the only spot in Sinai where we obtained the pretty little asphodel, (*Asphodelus tenuifolius*, Cav.)

GRANITE DENUDATION IN WADI LETIH.

previously found by the writer in Wadi Atilmi (Eastern Desert). The dykes of red felsite play an important part on the summit of Aad el Gharbi, giving rise to precipitous ridges forming a cock's-comb crest.

The plain of Wadi Aad is a favourite camping place with the Arabs, owing to the presence of a constant water supply in Wadi Moyyat el Aad. This narrow glen terminates in a fine ravine, where the boulders have been piled on one another in wild confusion, while in hollows between them are deep green pools of limpid and pure water. No ray of the sun penetrates its gloomy recesses, and the steep sides prevent the approach of ibex, leopard, and gazelle. Beyond, the valley opens out into smooth sandy expanses, where runnels of black sand line the grooves seamed in the soil by the storm-waters, and long mountain slopes rise on either hand, those to the west culminating in the peak of Gebel Aad. Looking from its summit northward, we see below us the thin boulder-stream of Wadi Mazea, and beyond the precipice wall of Gebel Haimar, while westward extends a long, thin crest, the watershed line connecting Aad with Gebel Sahara.

Gebel Haimar, rising grandly from the valley for over 1000 metres, projects forward from the main range, and is the highest point of a confused mountain system. A frontal attack would probably be attended with difficulty and even danger, but by ascending the flanking hills and crossing the ravine which descends its southern border, the highest crest can be approached from the rear, and can be crossed easily with the use of ordinary caution. The sense of bareness is also relieved by the presence of many bushes of *Zollikoferia spinosa* and *Anabasis setifera* on the mountain slopes, and it was remarkable to find a stone-circle on its steep sides. From its bend eastward Wadi Aad descends rapidly. On leaving the hills, it enters the plain as a broad depression bordered by gravel ridges and broad plateaux, from which rise isolated granitic hills and knolls. The most conspicuous of these is Gebel Dajilat, a typical low range of rounded granite slopes, often more awkward to climb than many of the more ambitious summits. In addition to this hill mass there are various isolated dyke ridges, which rise abruptly from the gravel plateau. Of these the most conspicuous are the Ras el Nimr and Ras el Hassainat. Circular bushes of sommu (*Cleome*) are abundant in this portion of Wadi Aad, associated with dafara (*Iphiona scabra*). Crossing the plain as a broad expanse, Wadi Aad becomes restricted between low cliffs as it enters the coral-reef region, and terminates in the delightfully secluded little bay of Aad, whose sandy shores are strewn with the rich shell treasures of the tropical sea.

Of secondary importance is the Awaja-Hedemia drainage system, consisting of bare desolate stony valleys taking their rise in low but steep hills, seen from the summit of Gebel Haimar to be a series of wedge-like ridges, running out into the valley with sharp points (due to dykes), and attaining their maximum heights in Gebels Um Markha, Awaja, Enumiah, and Fersh el Aad. In the upland portion are a few scattered seyal trees; sommu in low bushes of regular convex outline, and of rich yellow-green colour, and dafara, are the only vegetation, and here and there a waterpool was met with in out-of-the-way ravines.

The northern Wadi Awaja breaks through the hill barrier and grooving the granite plateau terminates in Sherm Bay. Sherm itself is of importance as having four wells, probably of ancient construction, but at the time of our visit the supply of water was very scarce, and it would not do to rely too implicitly on its presence at this spot. It is probable that the terror of the Arab on the opposite coast keeps this place absolutely deserted.

Sherm from whatever side it is approached is a striking spot owing to the strange colouring of the cliffs which surround it, those on the south being velvety-black above with deep tints of red in the lower half, while on the north the dead, white coral reef overlies bright-tinted sands. These combined with the blue waters of the inner bay form an effective combination, a picture not readily forgotten. Here morning, noon and night, with rare intervals, the breeze sweeps down from the north-east, becoming decidedly unpleasant when accompanied by rain, as was the case during our stay.

Sherm harbour is a well-known place of anchorage, one of the few along this reef-bound coast. The southern Wadi Awaja also breaks through the hill barrier, and for the major portion of its course is flanked on the south by a well-marked transverse ridge, Gebel Zafara; this hill, and the region generally, being well illustrated in one of the plates taken by the Pola Expedition. On the north is the low granite plateau, and the valley terminates seaward in the bay of Merza el Awaja, a sandy stretch which extends in a broad sweep from Sherm point to the projecting ledge at the foot of Zafara. When at Sherm the natives had informed us of the existence of a great inscription in this isolated spot, which naturally aroused our interest; our feelings may therefore be imagined when already some distance away we recognised two familiar Teutonic names painted large on a boulder, with a date underneath that marked too well its recent origin.

Wadis Hedemia and Madsus are the principal members to the south

of Gebel Zafara. These take their origin in the low hills bordering the upper portion of Wadi Aad and present no special features of interest, though Gebels Hedemia and Abuzag at the head of Wadi Hedemia have bold outlines and rugged crests.

When approaching the sea Wadi Hedemia, after passing some marked yellow hills about 200 metres high, is bordered by low cliffs of coral reef (a feature which is shared by all the minor valleys in this region), and terminates in a semi-circular bay very similar to that of Aad previously described. A noticeable feature in this region are the huge oysters which cover the summit of some of the low cliffs in Wadi Khorait, at the foot of Gebel Zafara.

South of Sherm the vegetation of the plains is very poor, being limited to galool (*a Zygophyllum*), dafara (*Iphiona scabra*) and dry bushes of markh (*Leptadenia pyrotechnica*) this being the only locality in Southern Sinai where this plant has been noted, while its presence here is of importance as a camel-food. Seyal trees are rare, except in the upper reaches of the valleys, while on the limestone reefs the dry woody Rose of Jericho (*Anastatica hierochunthina*) is everywhere present. Animal life is also very sparse in this region, though a short-bodied mantid is not uncommon, and a black stone-chat with white head was also noted.

South of Gebel Hedemia the hills rapidly lower, to the north being confused granite country, which further south is replaced by brightly tinted red and green crests, due to the extreme decomposition of dykes and rocks of allied nature.

Through this region Wadi Hashubi descends from the low watershed to the sea, being a wide and flat valley, in which arta (*Calligonum comosum*) and seyal were common. The arta at the time of our visit in January resembled dry wood, but even in that condition was readily eaten by the camels.

Two marked features distinguish this region from the remaining portions of Southern Sinai, blown sand covering the seaward slopes of the hills, in places almost to their very summits, while at the head of Ghazlani Bay such a sand-slope descends straight to the water's edge. On the other hand, most of the side-valleys in this region are filled with a flaggy sand-rock, forming terraces sometimes 10 metres thick, apparently connected with the drainage line. Where present these have precipitous sides towards the valleys, and in the wide gullies give rise to flat, smooth, level surfaces ending in abrupt vertical walls or steps, while the dykes rise through them in the form of low green and red ridges.

The peninsula of Sinai terminates in the long narrow promontory of Ras Mohammed, at its head being a limestone hill furrowed deeply by the wind-blown sand. The backbone of the peninsula is composed of a coral-reef limestone that has undergone much alteration, but which, expanding at the southern end, terminates in a bold cliff 100 metres high. On the northern side the beach of Ghazlani Bay (which is a wide inlet opposite the mouth of Hashubi) is covered with numbers of small Cerithia-like shells, associated with minute *Nerita* and bivalves, but as the rocky south end is approached it becomes more sandy. All round the eastern coast is a ledge of the lower reef, a shelf of coral which has the appearance of being suspended over the abyss, and beautifully blue-coloured fish disported themselves in the surf breaking over it. In places every slight depression in this reef is occupied by Ophiurids with blackish arms, here and there a brilliant red form (*Stylaster*) gives a pleasing dash of colour to the monotonous grey coral shelf, where small circular elevations rising from the general level curiously simulate miniature atoll structure. Further to the east in the small bays of the rocky coast, large crabs (probably *Grapsus*) are very numerous, apparently enjoying the surf which dashes over and around them. On the rocky islands which form the advance guard of the peninsula, the osprey finds a congenial home, while on the more open southern shore are hundreds of hermit-crabs, which have taken up their abode in every type of shell, *Murex tenuispina* included. The coral reef of the summit is exposed to the full fury of the gale, as is evidenced by its surface being furrowed and grooved in a north-east and south-west direction; in addition it has been in places rent asunder, the fissures trending normally east and west.

At the head of the peninsula is a small lake, which may be connected with the sea at high tide, the plain between it and the narrow channel which cuts off the southern point from the mainland being strewn with shells of the *Strombus* zone (see p. 139) this being also the case on the island itself. The separating channel is filled with shora trees (*Avicennia officinalis*) whose drooping deep green foliage contrasting with the dark-blue water forms a pleasing picture; on the island the osprey builds its nest, heron and egret also finding a resting-place in this forgotten spot, from whose bleak cliffs in years gone by the fleets of the then civilized world could be seen speeding their way over the blue waters of Akaba. In such wise ends the great central range and beyond this point descends an abyss fathom deep, while deep-blue waters stretch mile-wide on either hand, bordered only by the misty shores of Egypt and Arabia.

Region North of Wadi Nasb.

Differing materially from those previously described, to the north of Wadi Nasb is a region whose boundaries are shown on Plate XXII. At its second east-and-west bend this valley receives two important tributaries—Um Raiyig and Gura, the former being the continuation of the rift already described (see p. 27). The hills flanking Um Raiyig differ in structure, Gebel Hedjan el Gimal on the east being a dark-green crest with long talus-slopes to the valleys, while behind it the country consists of ridges of a striped schistose rock, the dip-slope in places being about 70 degrees south-east. —On the western side, on the contrary, are the smooth rounded granite or gneissose slopes of Gebel el Heyala, whose summit is a broken plateau, from which rise isolated knolls of well-bedded Nubian sandstone, these being striped in red and yellow bands and often beautifully curved. At the highest point is an ancient circle, having an inner mass of stone piled up on the southern side, and a doorway formed of two low upright sandstone slabs on the south-west. Other circles of more elaborate construction are present at a lower level. Dragon-flies were met with in great abundance while descending this hill.

Wadi Um Raiyig terminates at its northern extremity at the foot of Gebel Um Raiyig in a broad expanse, which has a garden-like aspect owing to the comparative abundance of seyal trees and *Zollikoferia* bushes. Further south the valley is reduced to a narrow passage by a tongue of granite projecting from the eastern side. To the east rises the great dome of Rai'emshi, the country traversed to reach it being composed of granite seamed by many dykes of dolerite and syenite. The hill itself owes its conspicuous character to the capping of sand-grit which, 114 metres thick, overlies the granite, and a slight fault in the hill has given rise to two summits, from the highest of which the view extends over a wide granitic plateau overlaid by numerous hillocks of sandstone. There are also many stone-circles scattered over the country especially in Alfara, two being also observed on the watershed between Erdini and Udai.

Immediately on leaving Um Raiyig, a district is entered which is topographically very confused, owing to the faulting already described. Large sandy plains serve as excellent camping grounds, and from these rise vertical masses of white sand-rock, 100 metres high, weathering to a faint pink colour; the basis of the plains themselves is often a hard ferruginous sandstone. In a district of this arid character, it would not be surprising if water and vegetation were entirely absent;

this is, however, not the case, there being a well in Wadi Shegera, a somewhat slanting hole cut down into the tilted Cretaceous rocks, the presence of the water being due to gypseous marls, which are probably also the cause of its being slightly brackish. In this connection it may be noted that the Arabs obtain supplies of salt from near the surface in the plain of Barga. The vegetation, though specifically poor, is characteristic, consisting of abundant retem bushes and a small daisy-like composite *(Anthemis melampodina)*.

Wadi Safra (the yellow valley), a tributary of Wadi Sa'al, is the most important drainage line on the western side of the sheet, and continues almost to the foot of the Gunna escarpment, which towers above the low country as a gigantic wall. The boundaries of the lower part of the valley are gentle slopes of granite, on which further north rest bright red, purple and yellow sandstones weathering to a uniform yellow-brown tint. In addition there is a very ornamental "tigerskin" variety, consisting of alternating bands of purple and white sandstone.

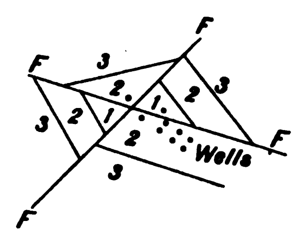
Above the purple and red beds rise outliers of white grit, forming bold precipitous buttresses often displaying a striking rectangular fretting on their flanks. The presence of a marked granite range almost under the slope of Gunna still further adds to the scenic complexity. The escarpment itself rises over 300 metres above the valley and extends in both directions as a solid wall, apparently unbroken as far as seen westward, but to the east shewing distinct evidence of the slow formation of isolated blocks through faulting and weathering. At its foot extend broad plains in which retem bushes are widely distributed, its summit being a broad rolling plateau, extending far to the north, probably to the borders of Wadi Zughera.

At the foot of one of the separated blocks (Gebel Hudera) is a ruined monastic building or *deir* 2·8 metres high, over 5 metres long and 2·8 metres broad, but slightly rounded at the corners. The whole is built of ferruginous limestone, 40·5 cm. thick, and pierced with windows 29·2 cm. high and 14·4 cm. broad, commanding a view of the hill. The door which faces eastward is as usual low, being just under 1 metre broad, 1·16 metre high inside, though stones heaped up outside have now reduced the height of the entry to 60 cm. The coping stone, over 2 metres in height, is not quite a metre above the door. Inside, the place was bare, except for some pieces of wood lying on the sandstone floor. From the summit of Gebel Rum a good view of the general relations of the escarpment were obtained, the latter

running back to the north, broken into by a series of huge bays, while to the east the fine cupola of El Ain rises in solitary majesty. To the north-east the country is a complex of dark sandstone resting upon granite, but a great maze of limestone is seen rising out of the midst of the range. The two hills of Abu Sowra and Um Rowa to the east are distinguished by the beauty of their colouring, being of delicate purple tints below and of a bright yellow colour above.

But the chief interest of this region centres round the beautiful little oasis of Ain El Hudera, which suddenly comes into view from the escarpment, a rich green gem set in the midst of stern and forbidding surroundings. Situated in a deep valley it is walled in on three sides by precipitous cliffs of sandstone though it is accessible from the south by a low pass; while to the north extends the broad wadi of El Hudera belonging to the El Ain drainage system. The Ain (Arab, "spring") itself consists of two important springs, one of which has been tapped at several points; some of these bores are deep, and clearly seen to be arranged along the line of a fault, which is continued in the small valley of Zarnuk Hudera. To the west of the main spring a second cutting has been made, the Arabs having in addition opened a groove, some 60 to 90 cm. deep, conducting the water to a small pond. The system of irrigation is primitive, a sluice being opened when needed, and water being in this way admitted along the shallow sandy canals. The chief objects of cultivation are date-palms, sidr *(Zizyphus spina-christi,)* yielding the nebk fruit, pomegranates (in full flower at the time of our visit), figs and barley or oats. The scene at this point is one of life and activity, blue rockdoves fly to and fro, while hundreds of hornets and dragon-flies bathe or hover over the water, and in the pond we noted for the only time a small worm-like animal with trumpet-shaped sucker, called "baluga" by the Arabs. In addition to the two main palm-groves, palms and rushes also grow in a small ravine close by, and it is curious to find numbers of *Melania tuberculata* in the sand, which in places lies thick round the palms. The walls of the tunnel through which the main spring is conducted are coated with salt, and are also the congenial home of large whip-like snakes.

The fault arrangement to which the water in all probability is due is shown in the accompanying figure, where 1, red granite; 2, the ferruginous sandstone; and 3, the white precipice-forming grits.



(Fig. 3).

Two passes lead over the watershed to Ain El Hudera, one a sheep-track winding down the steep face, while the path suitable for riding camels takes a more circuitous route to reach the valley. Baggage camels must of necessity go round by Um Rowa and Abu Sowra. Not far from the head of the sheep pass but lying on the main track to Akaba is an inconspicuous group of rocks (named by our Arabs Hejjaj), which seems to have received special attention at the hands of travellers, it being covered with inscriptions. Among these are Greek, Arabic, Cufic, and modern records, associated with spirited drawings of ibex, camels, and men riding camels in full movement. On leaving this point the road crosses the Nubian sandstone plateau, which is covered with a thin coating of sand and cindery blocks of black ferruginous sand-stone, this in its turn being intersected by sandy gullies, in some of which grow kebad and dafara, the latter probably driven out of the main valleys by the retem plant. Seyal trees are here very rare.

Further to the east commence a series of step-terraces, the one at the head of Wadi Ejjebi, soon after it receives Wadi Um Muthela, being very steep. This drop is due to a fault which has brought the white or battlement grits below or level with the coloured ferruginous series. A second drop occurring at the end of Wadi Khothayat obliged the baggage camels to go back to the previous camp and descend by Abu Khothayat into Um Rowa, but riding camels can reach the same spot by a shorter route. The valley arrangement at this point has already been illustrated in a paper by the writer * where the succession of limestone ridges and plateaux of Nubian sandstone capping masses of granite is shown to be such as would result from folding and step-faulting.

In the valley of Ejjebi is a grove of alradeh or alrathe, a graceful tree 2 to 3 metres high, having a pointed leaf somewhat like rimth (*Haloxylon Schweinfurthi*) and a white stem similar to that of a birch. From this point it was seen that great quantities of sand had been blown through the gap at the head of Wadi Haduda from the Barga plain. Descending Wadi Um Raib the mountain-wall on the eastern side of the valley gradually increases in height; still further south similar granitic peaks close it in on the western side, and down the centre of the valley lie scattered patches of sandstone and limestone. Wadi Raib is at first very sandy, the sand having been drifted against the numerous alrathe trees by the wind. An ascent of the eastern mountain wall at several points shows it to agree in all its main

* "The Rift Valleys of Eastern Sinai," Intern. Geol. Congress, Paris, Aug. 1900, p. 10.

characteristics with the hill-country bounding the Gulf of Akaba south of Dahab. The highest points are those immediately overlooking the valley, which lies 300 metres deep below, steep wadis, full of boulders, descending to it between cliffs of red granite. On their summits are many pleasant plateaux with small valleys issuing from them bright with ja'adeh, theman, kebad, and ausedj, but as the latter descend seaward, they become grooves or forbidding ravines, formed by the raging torrents during times of storm, and terminating in secluded sandy bays, beyond which the surf of the gulf beats incessantly against the coral reef which lines the shores. Yet in these now silent valleys man has been active, for at their head between the dyke ridges is a number of well-built stone circles and semicircles, most of them with an opening, apparently as a rule facing south. Strange, too, it is to find one single isolated mass of sandstone, some 20 metres thick, forming the very summit of Gebel Kharaza, a silent and dying witness of the great covering which the hand of time has almost entirely removed ; far below the same beds extend southward in the valley, and on the westward heights opposite the sandstone can be seen creeping southward, first in mass over the igneous rock, then breaking into knobs and isolated outliers, and finally giving place to the dyke ridges seaming the granite hills.

To our Arab guide the recesses of these distant hills are no mystery ; he knows that far below is a practicable road from Dahab to Noweiba, along which baggage camels go slowly across the Um Isma pass into Um Raisen, thence the track leads to Wadis Rassasa and Amaiyid, where is water with palms, and arrak bushes near the sea. This is, in fact, the last point north of Dahab where arrak (*Salvadora persica*) is to be met with, asella (presumably *Suæda monœca*) taking its place between Noweiba and Akaba. Many minor tracks traverse these hills, these mainly leading to Wadis Amaiyid or Lebba. On the western side of Um Rai'b the conditions are very similar, most of the wadis (such as Abu Somra and Abu Habba,) commencing as smooth-bedded sandy valleys, dotted with seyal trees and kebad bushes, but at the edge of Wadi Raib giving rise to a series of precipitous ledges (Arab., "sidd") alternating with typical boulder-gully. These boulder-valleys are at times very dangerous, and on the last day of work one of the men slipped down one of these for over 10 metres, but happily escaped with only a severe shaking. These "sidds" were always a source of anxiety if the work were not terminated by nightfall, the most dangerous being usually those nearest the valley.

The season's work terminated at the mouth of Wadi Raib, and the subsequent march to Tor being made as rapidly as possible, there was but little opportunity for detailed observation. The return road first lay through the ravine of Wadi Nasb, and then entered the truly magnificent gorge of Wadi Gura, where huge precipices towered for hundreds of metres above the narrow and winding ravine. On entering Wadi Zagara and approaching Habshi, the schists again made their appearance, the country opening out in consequence, and having the depressing green colour and barren character of such regions. Near Senned the granite reappears in force, and the track winds among the low, rounded pink hills until it opens out into the great plain of Senned, at the time of our passage in May, filled with bushes of *ajerum* and the smaller *haremlan*, the latter said by the natives to be good for toothache. To the south of the plain extends the great ridge of Um Allowi, while to the west a low and easy path across the watershed leads into Wadi El Sheikh opposite the well-known tomb of Sheikh Saleh. From here a flying visit was paid to the Convent and Holy Mountain, a well-kept road leading to the summit of Gebel Musa, which as has often been remarked is entirely unsuitable as the centre of the grand events described in the Book of Exodus, deep beneath being but narrow clefts and barren unimposing valleys. The great spur of Safsafeh, on the other hand, commanding as it does the wide plain of Er Rahab and the Wadi El Deir, is a suitable spot for the promulgation of the Law, and this isolated region, hidden behind rocky barriers and possessing one of the most invigorating climates in the world, is fit indeed to change a horde of Oriental slaves into a nation of hardy warriors. There is undoubtedly a charm around this ancient crest, which Christian, Hebrew, and Moslem alike regard as one of the holiest centres of their religions. As we ascend, high plants of *Verbascum*, reminding us of the familiar mullein at home, blossom on the roadside, while the summit (in late May and early June) is clothed with myrrh (*Pyrethrum santalinoides*), which when crushed under foot exhales a powerful aromatic odour.

Here, side by side, are the two small buildings devoted respectively to Christian and Moslem, while on neighbouring heights rise crosses, marking the traditional site of some famous Biblical scene, annually visited by the Russian and Greek pilgrims who are personally conducted by the monks to the holy places. Far down in the valley below is the Convent-fortress, which since the days of Justinian has stood as the last relic of monastic influence, its dark-green cypress trees lending an unexpected beauty to the wild scene in which they find a home.

PLATE XII. (a)

SINAI CONVENT.

PLATE XII. (b)

GARDEN OF SINAI CONVENT.

Descending from the Convent by Wadi El Sheikh the road passes through the cleft of El Watiya, a narrow winding gap which forms one of the important points of connection between Sinai and the outer world. Immediately on passing the gorge the country opens out, many-dyked granite hills lying to the north, while in the valley itself is a grove of tamarisk trees bordered by remarkable light-coloured terraces. At the time of our visit these graceful trees were filled with a dark locust-like insect, a Cicada, and were exuding a very sweet transparent gum, appearing like drops of water, and known to the Arabs under the name of "man". It has been stated that the insect above-mentioned plays an important part in the production of the *man* but this point it was impossible to determine owing to lack of time, the locusts themselves being very difficult to discover, although the rustling in the trees showed them to be present in large numbers.

Descending Wadi Gharbi the well-marked gneissose district was entered, where coneys were busily engaged running underneath and between the boulders, while a spiny-tailed *Uromastix* sought shelter in the clefts of the rock. At eventide the scene crossing the low plateau at the head of Wadi Hebran was beautiful in the extreme, the serrated ridge of the mighty mass of Serbal showing slate-grey in the evening light, while beyond the deep valley the great dome of Madsus still glowed rose-red, then gradually faded into purple at approach of night. Wadi Hebran with its many palm-groves, its running streams, its rugged bounding-hills, is a beautiful spot, torn in winter by many a rushing torrent, as is seen by the present condition of the broad road which Abbas Pasha made when he lived in his Sinai palace, now standing forlorn and desolate. Passing from the hills through a narrow gap, the valley for a short distance extends seaward as a shallow groove, finally opening out into the vast plain of El Qa'a stretching westward to the sea. Owing to the stringency of quarantine regulations at Tor, the return to Suez involved a further six days' traverse of the desert, first across the sun-swept plain of El Qa'a, thence skirting the seashore across the plain of Markha, past the cape of Abu Zenima and the great black dyke of Tayiba. Thence bending desertward through the valley of that name past the palm and tamarisk groves of Useit and Gharandel, the "great and terrible wilderness' is entered, where the sand sweeps in blinding eddies along the camel-track, the low gypseous hills enhancing the desolation, while everything is distorted by ever-present mirage. After two days' traverse through this monotonous and

arid waste, welcome indeed is the sight of the palm-groves and seven springs of Moses' Wells, the desert outpost of Suez, where terminated our eight months' wanderings in this inhospitable but interesting wilderness.

CHAPTER IV.

BOTANICAL NOTES.

Sinai has been the scene of numerous botanical explorations, the following being the most important.* Ehrenberg and Hemprich visited Egypt, Arabia Petræa, and Syria from 1820 to 1823, and brought back collections which were never described. Dr. Rüppel, who made a careful examination of Sinai between 1822 and 1826, also made a collection, which was recorded in his "Beiträge zur Flora Aegypten und Arabien." The plants brought by Bové in 1832 were determined by Decaisne, and published in the "Annales des Sciences Naturelles," under the title of Florula Sinaica.

In 1835 Schimper made a detailed examination of the Mount Sinai neighbourhood, and Boissier in 1846 also visited the same district, while in 1867 he summarized the whole of the previous observations in his monumental work, the "Flora Orientalis," which also forms the basis for a useful flora published by Post.

The botany of Western Sinai has during past years been the subject of detailed studies, the results having been brought together in Boissier's monumental work, and further summarized in Post's "Flora." A collection was also made by the Ordnance Survey which under Sir C. Wilson mapped this district, the plants having been named by Sir J. Hooker. A valuable collection has recently been made by Herr A. Kneucker, who in an expedition from Tor to Suez through the central mountain range between March 30and April 13, 1903, obtained 272 species of phanerogams, or more than half those recorded in our list, the results for the cryptogams were particularly valuable, of 20 species of Bryophyta no less than 14 being new to the peninsula. All the algæ in our list are also due to this expedition except the Diatomaceæ, which were more especially noted by the Ordnance

* See BOISSIER, "Flora Orientalis," Vol. I. p. XXI.

VIEW OF SINAI FROM GEBEL KATHERINA.

Survey, while the Ayun Musa forms were collected by Drake, Fraas, and Wilson; and those of Tor by Haig.

Where plants have been collected by members of the Geological Survey, these are marked respectively as Hume or Barron Coll., and the authority for the name in most cases is Dr. Schweinfurth, who kindly helped the author in this important respect; the Kneucker Coll. is next given precedence, as this botanist kept careful account of localities and mode of occurrence. He did not, however, obtain the Arabic names, and the authority for these is shown by the initials P.F. = Post's Flora, or O.S. (Ordnance Survey).

The authorities for Herr Kneucker's identifications are given in a paper entitled "Botanische Ausbeute einer Reise durch die Sinaihalbinsel" in Allgm. Botan. Zeitschrift n° 7–8, 1903. It is satisfactory to know that the same botanist is now undertaking an examination of the Eastern Sinai region, Herr Guyot at the same time collecting the insects, so that further valuable observations may shortly be expected.

In the Egyptian Geological Survey Report on the "Topography and Geology of the Eastern Desert of Egypt" a list of 50 plants was given, representing the most typical members of the desert flora between lats. 26° and 28° N. in that region. A similar collection, embracing 56 species, has been made by the writer in Eastern Sinai, the majority of these being, as in the former case, most kindly named by Dr. Schweinfurth. These identifications are not sufficient to enable the botanical position of Eastern Sinai to be determined in relation to the better known districts lying to the west of the Gulf of Suez, but by comparing the results in Schweinfurth's and Ascherson's well-known flora and the list given in this work, a good idea of its true relationship may be obtained.

Resemblance of Eastern Desert and Sinai Flora.

A glance at the appended list is sufficient to show that in their broad outlines the two regions have a close resemblance, two-thirds of the Sinai species also occurring in the eastern Egyptian desert, but an examination of details shows some interesting points of difference.* In the Eastern Desert flora are a number of species which are evidently of southern origin, and have obtained but little footing in Sinai. The most notable of these are the *Cocculus Laeaba*, which is an abundant climbing plant in the Sudan; *Morettia phileana*, one of the most widely

* The writer has not had the opportunity of revising this list in the light of the new material collected by Herr Kneucker, but it is not probable that the relations would be materially altered.

distributed crucifers in the valleys of the cataract district and in the larger wadis north of the Qena-Qosseir road, has rarely been noted in Sinai,* while the beautiful *Moringa arabica*, which seems specially suited to the secluded glens of this mountainous region, was totally absent on the eastern side, though Barron informs me that it occupies a definite zone in Wadis Hebran and Mear on the western. Other notable absentees are the *Acacia Ehrenbergiana*, one of the most widely-spread of eastern desert and Sudan shrubs, and in Eastern Sinai the Asclepiad *Daemia tomentosa*, another widely distributed Egyptian desert plant, though the latter has been recorded in various Sinai lists as present on the western side.

CHARACTER OF FLORA AT SOUTHERN END.

In this connection special attention may be called to the extreme southern end of the peninsula, where a few of the most important members of the eastern desert flora have succeeded in obtaining a precarious footing. The *Leptadenia pyrotechnica*, which forms one of the most conspicuous bushes in mountain valleys north of Qosseir, only occurs in a stunted form in the neighbourhood of Sherm, and northward along the line of the Dead Sea rift, while the *Avicennia officinalis*, the large willow-like mangrove which fills many of the bays north of Qosseir, has only succeeded in establishing itself in the small channel between the island and the mainland at the south end of Ras Mohammed and along the shore near Nebk.

CHARACTERISTIC PLANTS.

Undoubtedly the most widely distributed of all the South-east Sinai plants is the low prickly composite *Iphiona scabra*, which when eaten too freely by camels or ibex forms a compact fibrous ball in their intestines, eventually by its growth causing the death of the animal affected. Other characteristic plants are *Otostegia microphylla*, *Gymnocarpus decander*, and *Pyrethrum santalinoides*. On the other hand many eastern desert plants are quite as much, if not more, widely distributed in Sinai, among these being *Artemisia judiaca*, *Salsola fœtida*, *Calligonum comosum*, *Capparis spinosa*, *Ochradenus baccatus*, *Zollikoferia spinosa* and the seyal (*Acacia seyal*). *Salvadora persica* extends along the coast of the Gulf of Akaba as far as Noweiba, where it is replaced by

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* In Qa'a plain, by Kneucker.

the asal, presumably *Suæda monœca*. The rarest of all the plants in this district is the single representative of the Umbelliferæ, *Zozimia absinthifolia*, found near the head of Wadi Humr, and previously recorded from Gebel Um Khasheyba east-north-east of Suez by Figari, on the high plateaux at the origin of Wadi Jendeli, and between the heads of Wadi Warag and the upper Wadi Rischrasch. *Malva rotundifolia* was only noted as a small patch at the head of Wadi Letih, but may have been cultivated by one of the Arabs.

Distribution of Plants.

There are some noticeable differences in the distribution of the various species according to height and rock-structure. In the great plain (Qa'a Plain) on the western side of Sinai near the sea, only a few Zygophyllaceæ, mainly *Zygophyllum album*,* seem able to survive the inhospitable conditions, *Aristida caloptila*, *A. plumosa* and *Danthonia Forskalei* taking its place in the central portion, and *Artemisia judaica* becoming very abundant as the mountains are approached. Immediately the mountain-valleys are entered, the vegetation becomes relatively abundant and varied—palms, reeds, seyal, tamarisk and jungle of bulrush and reed beautifying many an otherwise wild and rugged mountain glen. The familiar *Zilla myagroides*, *Zollikoferia spinosa*, and *Artemisia judaica* line the more prominent water-channels, while bushes of *Capparis spinosa*, with bright green leaf and large yellow flowers, occupy many a precarious foothold in the clefts and crannies of secluded ravines. After crossing the central chain into Wadi Nasb *Salsola fœtida* was noted as being one of the most prominent of the valley shrubs, and large bushes of *Gomphocarpus fruticosus* filled the air with their scent in the upper portion of Um Gerat. On the eastern side scattered seyal are grouped at the heads of the small valleys draining the steep-sloped central chain, while in their lower portion as they widen seaward, prickly shrubs of *Iphiona scabra* and *Cleome droserifolia* diminish the bareness of an otherwise desolate region.

A few lists may here be given showing the typical distributions in some of the principal valleys:

Wadi Isla: Palms, reeds, phragmites, *Artemisia*, maidenhair fern (*Adiantum*) in small streams.

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* Kneucker states the desert plains are characterized by succulent *Zygophylla*, *Chenopodiaceæ*, *Aristida*, *Danthonia Forskalei*, *Brocchia cinerea*, *Artemisia cinerea*, etc. See also A. Kneucker (Allg. Botan. Zeitschrift N° 7-8, 1903.

Wadi Naab: *Salsola*, tamarisk, palm, reed, bulrush, *Capparis*, *Calotropis*, *Artemisia*.

Crossing the transverse range there is a marked change:

Wadi Rahab: *Crotalaria*, *Iphiona*, *Aerua*, *Zilla*, *Zollikoferia* and *Salsola*.

At head of Wadi Kyd: Many *Capparis*, gazuch (smelling like a carrot), *Retem*, *Zilla*, *Zollikoferia*, *Artemisia*, *Lycium arabicum*.

In lower part of Kyd: *Calligonum*, *Diplotaxis*, *Artemisia*, *Zilla*, *Cleome* and *Ochradenus*.

In the upper reaches of Wadi Letih there was a very varied vegetation, especially in the boulder-valleys entering it from the central hills. Among these the Labiate genera *Otostegia* and *Lavendula* are conspicuous.

In addition the following were noted: *Robbairea*, *Trigonella*, *Zollikoferia*, *Artemisia*, *Diplotaxis*, *Achillea fragrantissima*, *Anchusa*, *Capparis*, *Lycium*, *Solanum retroflexum*, *Picris* sp. and *Malva rotundifolia*. Numerous other flowers are present, having the following Arabic names: raffiya, glayitterai (a plant with soft leaves and a yellow flower), lassag (? *Forskalia*), daha and hotham*. The flora of this region has been described in greater detail owing to its being somewhat off the beaten track.

MOUNTAIN FLORA.

While the plants of Sinai are undoubtedly most abundant in the deep valleys and boulder-strewn ravines, there is a very definite flora which flourishes more readily on the bare mountain slopes or even on the wind-swept summits. Two of the most typical members are the aromatic composite *Pyrethrum santalinoides*, which at the time of our ascent of Gebel Musa covered the slopes immediately beneath the summit, every step crushing these odoriferous plants, and the air being heavy with their scent. Another plant of still wider distribution on the eastern side of Sinai is *Anabasis setifera*, which has been noted on the summit of most of the important mountains in the peninsula, (especially abundant on the summits of Fersh Sheikh el Arab, Beidha, Asafia and Aleg).

On Sabbagh, on the contrary, two other plants took their place, one a

* Special attention may also be called to a small tree from two to three metres high, which has a jointed leaf resembling that of *Haloxylon Schweinfurthi* and a white stem similar to that of a birch. These are known to the Arabs as "alrada" or "alratha" and occur in abundance at the head of Wadi Raib.

small *Artemisia*-like fragrant composite, the shia el gebel (Arab.), and the other a spiny thistle, probably an *Echinops*, which has a disagreeable habit of growing on the rock-ledges by which the ascent has frequently to be made. On Um Adowi the heads of the valleys immediately below the summit are filled with *Lycium arabicum*, *Zollikoferia spinosa*, a small *Iphiona*, probably not *scabra*, the dafara el gebel (Arab.), *Otostegia microphylla*, and a plant known as gethib. On Haimar *Zollikoferia spinosa* and *Anabasis setifera* ranged almost to the very summit, while jeradeh* (? *Gymnocarpus*) filled the heads of the high valleys in Gebel Gnai.

Streaming of Flora.

On the other hand, the Akaba gulf plain flora is not extensive, being limited in the main to palms (as at Dahab and Nebk), *Salvadora persica* bushes, reeds of various kinds, *Iphiona scabra* and pulpy-leaved *Zygophyllum*. An interesting feature in Sinai is the *streaming* of the flora of one region into another along the line of the rift-valleys. When Dahab was reached it was noticed that *Haloxylon Schweinfurthi* made its appearance for the first time, and on tracing the plant-life of Wadi Nasb it was found that this plant ceased east of its junction with Wadi Sa'al coming from the north. A subsequent traverse showed that *Haloxylon Schweinfurthi* was abundant in the latter valley, associated with *Retem retama*, which similarly had been able to extend southward along this deep groove in the granite hills.

Retem is in fact, with *Haloxylon Schweinfurthi* and *Anthemis melampodina*, the characteristic plant of the northern portion of mountainous Sinai, being the most conspicuous feature in the plains and larger valleys lying between the Cretaceous escarpment and Wadi Nasb. The portions of Sinai studied may be roughly divided into several zones. 1. The *Retem-Haloxylon Schweinfurthi* zone, embracing the high plateau country above mentioned. 2. The *Iphiona scabra* zone, including the triangle enclosed between the triple watersheds, and having an *Aerua* sub-zone, the arid schistose region south of Dahab where the *Aerua javanica* alone appears to flourish. 3. *Anabasis setifera* and *Pyrethrum santalinoides* zone, this including the mountain summits and slopes. 4. The *Zygophyllum album* zone of the Great Plain. 5. The *Salvadora persica* zone of the Akaba coast.

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* This plant requires closer examination.

The following notes deal with the distribution of the natural orders and the species composing them:

Distribution of Natural Orders.

I. The *Cruciferæ* are represented by five species in the collection: 1. *Mathiola arabica* according to Hooker; 2. *Shouwia arabica;* 3. *Diplotaxis harra* (Forsk.) (see Boissier I. 388) is a small plant bearing a yellow cruciferous flower with four long and two short yellow stamens and one long pistil with yellow point. It was especially noted in Wadi Letih and its tributary valleys. 4. *Zilla myagroides*; and 5. The rose of Jericho (*Anastatica hierochuntica*), the well-known dry-looking ligneous plant which expands its woody-looking flower when placed in water, and one of the commonest plants on the coral terraces bordering the Gulf of Akaba. The other species are all of frequent occurrence in the mountains. The *Zilla myagroides* is here, as in the eastern desert, one of the most characteristic of the desert plants, occurring in bushes in the valleys, and easily recognised by its prickly branching and white to purple cruciferous flowers. It extends throughout the peninsula to the shores of the Gulf of Akaba, giving its name to Wadi Um Bsilla, one of the branches of Wadi Letih.

II. *Capparidaceæ.* The genus *Capparis* belonging to this order is of wide distribution, being abundant in the high valleys of the granitic region, and generally known to the Arabs of both Egypt and Sinai under the name of lassaf, while its peppery fruit is much sought after by the desert dwellers. The principal species is *Capparis spinosa* (Boiss I. 420). In Sinai it occurs in all the main valleys, and is also common on the slopes of Gebel Tellat Unsair, and in the higher valleys of the Ferani range.

Cleome is another representative of the Capparidaceæ in Sinai, the most striking species being *C. droserifolia*, Del. (see Boiss. I. 415), which has a drosera-like leaf covered with small prickles, and usually occurs in small semi-circular bushes having a disagreeable smell. It is probable that the "sommu" of Southern Sinai is this species. *Cleome brachycarpa* and *C. chrysantha* appear to be invaders from the south.

III. *Resedaceæ.* This natural order is represented by the abundantly distributed bushy *Ochradenus baccatus* Del. (see Boiss. I. 422.), which appears to be limited to the main mountain valleys in Sinai, being very noticeable in Wadi Hammam (Sa'al), Nasb and Kyd. The small

mignonette *Reseda pruinosa*, has been recorded by Sir J. Hooker from the collections made by the Ordnance Survey in Sinai. *Reseda stenastachya*, Boiss., appears to be a local form.

IV. *Silenaceæ.* Among the collection made at the head of Nasb there was a small plant with very hairy leaves and a small yellow flower, *Silene villosa*, Forsk. (see Boiss. I. 592). This plant was also found at the head of Wadi Letih. Of even more frequent occurrence on the mountain slopes at the head of Wadi Humr is *Gypsophila Rokejeka.* This order is especially rich in local species.

V. *Paronychiaceæ.*—This order is represented by the small *Robbairea prostrata*, and possibly by the important mountain plant *jeradeh*, provisionally referred to *Gymnocarpus decander*, abundant on Um Zeinig and Gnai.

VI. *Tamariscaceæ.*—The tamarisks are among the most characteristic members of the Sinai region, groves of these trees filling the broad valley of El Sheikh near the head of Solaf, while they also lend beauty to the deep ravines of Eastern Sinai, being especially abundant in the gorges of Wadi Nasb. The commonest species is perhaps *Tamarix mannifera*, Ehrenb. (see Boiss. I. 975) from which exudes the sweet gum known to the Arabs as *man*. In May the Solaf groves were infested with a form of *Cicada*, which crowded every branch and had probably been attracted by the manna. The general Arabic name is tarfa and owing to these trees being largely used by the natives for fire-wood many fine tamarisks are annually destroyed, there being no effort made to replace the waste.

VII. *Molluginaceæ.*—A small *Glinus* is the only member of this order recorded, being known to the Arabs as lepetha.

VIII. *Malvaceæ.*—The only example of this order, the kobbeyza *Malva rotundifolia*, has already been referred to.

IX. *Geraniaceæ.*—At the head of Wadi Aad a small plant was obtained to which the Arabs gave the name of dahemi, and as it showed the characteristic fruit of the stork-bills, was noted as one of the Geraniaceæ. The species is possibly *Erodium bryoniæfolium*, Boiss., described by Post under the name of dehamin.

X. *Zygophyllaceæ.*—This order is the most widely represented in the limestone deserts, where everything seems to be against the growth of vegetation. Various species are of common occurrence in Sinai, the principal forms belonging to *Zygophyllum* and *Fagonia*, most frequently met with in the plain of El Qa'a and that bordering the Gulf of Akaba. The ghargad (*Nitraria tridentata* or *retusa*) grows abundantly in Wadi Sa'al and on the shores of the Gulf of Akaba, where its sweet berries attract hundreds of hermit-crabs.

XVI. *Rhamnaceæ.*—This order is represented by the sidri tree (*Zizyphus spina-christi*), whose small crab-apple-like fruit, known as nebk, is a favourite food among the Arabs. It is only present in some of the more favoured valleys, and especially in the recesses of Wadi Kyd.

XVII. *Moringaceæ.*—The beautiful *Moringa*, though present on the western side of Sinai, (apparently with a definite height-zone according to Barron), does not appear to have crossed the watershed, and is therefore not included as a member of the Eastern Sinai flora.

XVIII. *Leguminosæ.*—As might be expected, this order is of great importance in Sinai, including some widely-spread members. Among these the most conspicuous is the *Retama rœtam*, Forsk., which is the most characteristic bush in the north of Sinai, though its range also extends southwards along the rift valleys. Species of *Astragalus* are also of common occurrence, and the senna (*Cassia obovata*) is widely distributed in the lower reaches of Wadi Nasb, where its familiar yellow flower and characteristic fruit cannot fail to be noted.

But most important of all are the *Acacias*, which under the name of seyal beautify the upper reaches of the valleys, supply fuel and food-supply for the camels, while the native dweller himself does not despise their leguminous pods. Unfortunately the formidable spines of these trees, which are often strewn round their bases, detract from their value as shade-givers, while the gum which exudes from their stems attracts innumerable insects and especially ants. This is reputed to be the "shittim" of the Biblical record. The poisonous *Lotus arabicus* is also a member of the local flora, and on the western side are graceful little *Trigonellas* and *Lotononis*.

Members of the Rosaceæ and Crassulaceæ were never met with during our expedition, and the Cucurbitaceæ were also but feebly represented, *Citrullus colocynthis*, L., so common a member of the eastern desert

flora, being but rarely observed. The same statement applies to the Umbelliferæ, (*Zozimia absinthifolia*, Vent.) having been only once noted at the base of Gebel Asafia. It is possible that a plant smelling like a carrot, and known as Qasuch according to Post, may be the *Deverra triradiata*, Hochst., belonging to this order. On the western side, Um Shomer receives its name from the abundance of *Ferula sinaica*, Boiss., Arabic name = Shomer.

XXVI. *Compositæ.*—As might be expected, this great order includes some of the most striking members of the Sinaitic flora, and one plant, *Iphiona scabra*, D.C., is practically characteristic of South-east Sinai. Reference has already been made to the dangers incurred by eating this plant, its fibres forming a solid ball in the stomach, and eventually leading to the death of the animal affected. In the northern plain *Anthemis melampodina*, Del., takes its place, growing in isolated plants rather than in low bushes, and has a strong resemblance in form to a daisy. Here belong a large group of aromatic plants, including the fragrant *Pyrethrum santalinoides*, D.C., which covered the summit of Sinai in June and is a characteristic mountain flower, while in the valleys the yellow-flowered *Artemisias* are in even greater abundance. The thistle '*Echinops glaberrimus*, D.C., is at times unpleasantly conspicuous, while a mustard (*Senecio flavus* Schz.), with modest yellow flower, hides itself among the nooks and crannies in the boulder valleys.

Constant reference has been made to *Zollikoferia spinosa*, Forsk., whose spinose bushes are distributed alike on mountain-side and in deep valley.

XXVIII. *Salvadoraceæ.*—*Salvadora persica*, Garcin. is the characteristic shore plant of the Gulf of Akaba, its straggling tangled stem extending equally in all directions, so that the bush produced is low, widely spread, and strikingly circular in form. According to the Arabs, it is not present to the north beyond Noweiba.

XXIX. *Asclepiadeæ.*—The Asclepiads are similar to those already recorded from the Eastern desert, the highly-scented hardjel (*Gomphocarpus sinaicus*, Boiss.) with bunches of white flowers and pear-shaped fruit being present in many of the mountain valleys. The local distribution of *Calotropis procera*, Willd.* is peculiar, it being

* This plant is really a southern form, being of wide extension in the Sudan, where it grows freely as a weed on land which has gone out of cultivation. The milky sap of its thick leaves has a highly poisonous character, when applied to the eyes, producing blindness.

relatively abundant in the higher reaches of Wadi Gnai while elsewhere it is seldom met with. *Leptadenia pyrotechnica*, Forsk., is also limited to the southern extremity of the peninsula. The *glayitterai*, of which no specimen was preserved, is possibly a *Dœmia*, but the familiar *Dœmia tomentosa* was not noted by the writer, though observed by the Ordnance Survey.

XXX. *Borragineæ.*—Plants of this order are fairly abundant, the hamima, of the Ordnance Survey, being probably our ekhmim (*Trichodesma africanum*, L.) from the northern sandy plains, while *Anchusa Milleri*, Willd. is ubiquitous.

XXXI. *Convolvulaceæ.*—This order is rare in Eastern Sinai, only one example of *Convolvulus hystrix*, Vahl., being obtained at the foot of Gebel Gnai where it forms large bushes. In Western Sinai, and especially in the northern portions, it appears to be more extensively represented.

XXXII. *Solanaceæ.*—This order includes several poisonous members, *Solanum retroflexum* strikingly resembling the woody nightshade of England and northern Europe. One large bush, *Lycium arabicum*, Schw., is also of frequent occurrence as in Wadi Sa'al, but the most common of all are the sekkerans (species of *Hyoscyamus*) whose bright-coloured flowers rising on thick stalks among foxglove-like leaves at once arrest attention wherever present.

XXXIII. *Scrophulariaceæ.*—Although a number of species of this order have been obtained in the peninsula (see list), the individuals must either be rare or insignificant in Eastern Sinai, as they are unrepresented in the collections made. On the western side it was otherwise, the large and fine-flowered mullein (*Verbascum sinaicum*, Bth.) being one of the most conspicuous plants on the slopes of Mount Sinai when ascended by us in May, 1899.

XXXVIII. *Verbenaceæ.*—This order is represented by *Avicennia officinalis*, L. which, as already remarked, grows abundantly at isolated points on the shores of the Gulf of Akaba.

XXXIX. *Labiatæ.*—This order, next to the Compositæ, Leguminosæ, and Zygophyllaceæ, is the most important in Sinai, and is relatively more widely distributed than in the eastern desert of Egypt. Among

the larger mountain bushes the ghassa (*Otostegia Schimperi*, Bth.) is both conspicuous and common.

XLI. *Amarantaceæ.*—The *Aerua javanica*, Juss. is with its wooly head one of the most widely distributed of plants in the barren portions of the peninsula, and especially in the dark schistose region, where it alone relieves the otherwise absolute desolation.

XLII. *Chenopodiaceæ.*—This order includes three very important members of the Sinaitic flora, viz. *Haloxylon Schweinfurthi*, which fills the northern tributaries of Nasb, streaming from the sandy plain region; *Anabasis setifera*, Moq., present on every important mountain summit, and *Suæda monœca*, Forsk. which is the characteristic Akaba shore-plant north of Noweiba.

XLIV. *Polygonaceæ.*—During the spring the young shoots of *Calligonum comosum* attract many gazelle to the lower reaches of Wadi Kyd, and it extends its range to the southern end of Sinai (Wadi Hashubi), where even the dried woody stems are a much-appreciated camel-food. On the other hand, *Rumex vesicarius*, L., which is of frequent occurrence, is welcome to the natives, having a taste strongly resembling the familiar sorrel.

LI. *Liliaceæ.*—Lilies are but poorly represented, *Asphodelus tenuifolius*, Cav., being limited to the central ranges.

LIV. *Palmæ.*—The presence of the date-palm (*Phœnix dactylifera*, L.) has been frequently mentioned in previous pages, it being always present in the more favoured spots.

LV. *Gramineæ.*—This important order has many representatives, but undoubtedly the most conspicuous is *Panicum turgidum*, Forsk. which was everywhere met with in suitable localities.

LIX. *Filices.*—The maiden-hair fern (*Adiantum Capillus veneris*, L.) grows near the small streams which lend a special beauty to the ravines of Isla, Hebran and Kyd, and is also sometimes found lining the small water-pools which are hidden away among the higher mountain-ranges.

SUMMARY.

The principal conclusions are as follows:

1. The Sinai flora greatly resembles that of the eastern Egyptian desert, two-thirds of the species in the former area being common to the latter.

2. In Southern Sinai are a few Egyptian members not elsewhere present in the peninsula.

3. The distribution of characteristic plants is indicated, the following zones being recognized:—

   a. High plateau (sandstone country) characterized by *Retama rœtam* and *Haloxylon Schweinfurthi.*

   b. Valleys of the mountainous or hilly central portion of South-East Sinai with *Iphiona scabra.*

   c. An arid schistose sub-region in the above with only *Aerua javanica.*

   d. The mountain summits with *Anabasis setifera* and *Pyrethrum santalinoides.*

   e. The western plain with *Zygophyllum album* and species of *Aristida.*

   f. The Akaba coast-plain with *Salvadora persica* and *Avicennia officinalis* in the bays.

   g. The coral-reefs with *Anastatica hierochunthica.*

4. The *streaming* of the flora of the high plateau 3a along rift or fault-valleys into the region 3b.

5. A consideration of the principal natural orders in Eastern Sinai and their salient species.

ARABIC NAMES OF PRINCIPAL SPECIES MENTIONED IN THIS PAPER.

NATURAL ORDER	SPECIES	ARABIC NAME
Cruciferæ	*Matthiola arabica*, Boiss.	Khom-khom
do.	*Shouwia arabica*, D.C.	Nam-nam
do.	*Diplotaxis harra*, Forsk.	Harra
do.	*Zilla myagroides*, Forsk.	Bsilla
Capparidaceæ	*Capparis spinosa*, L.	Lassaf
do.	? *Cleome droserifolia*, Del.	Sommu
Resedaceæ	*Ochradenus baccatus*, Del............	Gurdi
Silenaceæ	*Silene villosa*, Forsk.................	Kahali
do.	*Gypsophila Rokejeka*	Sirr

ARABIC NAMES OF PRINCIPAL SPECIES MENTIONED IN THIS PAPER, *(continued)*.

NATURAL ORDERS	SPECIES	ARABIC NAME
Paronychiaceæ	*Robbairea prostrata,* (Forsk.) Boiss...	Enjiada
do.	*? Gymnocarpus decander*	Jeradeh
Tamariscaceæ	*Tamarix*, sp.......................	Tarfa
Molluginaceæ	*Glinus*, sp........................	Lepetha
Malvaceæ...........	*Malva rotundifolia*, L...............	Khobbeyzeh
Geraniaceæ	*Erodium bryoniæfolium*, Boiss	Dahemi
Zygophyllaceæ	*Zygophyllum album*, L.	Bowal
do.	*Nitraria tridentata*, Desf.	Ghargad
Rhamnaceæ.........	*Zizyphus spina-christi,* L.	Sidri
Leguminosæ	*Retama retam,* Forsk.	Retem
do.	*Cassia obovata*, Collad.	Senna
Cucurbitaceæ	*Citrullus colocynthis*, L..............	Handal
Umbelliferæ	*Zozimia absinthifolia*, Vent..........	Kalth
do.	*Deverra triradiata*, Hochst...........	Qasuch
do.	*Ferula sinaica*, Boiss.	Shomer
Compositæ	*Iphiona scabra*, D.C.	Dafara
do.	*Anthemis melampodina*, Del.	Erbayan
do.	*Pyrethrum santalinoides,* D.C.	Myrrh
do.	*Artemisia judaica*, L................	Betheran
do.	*Senecio flavus*, Schnz.	Wein
do.	*Zollikoferia spinosa*, Forsk.	Kebad
Salvadoraceæ	*Salvadora persica*, Garcin	Arrak
Asclepiadeæ....... .	*Gomphocarpus sinaicus,* Boiss.	Hardjel
do.	*Calotropis procera,* Willd.	Ashara
do.	*Leptadenia pyrotechnica*, Forsk.	Markh
Borragineæ..........	*Trichodesma africanum*, L...........	Ekhmim
do.	*Anchusa Milleri*, Willd.............	Kahali
Convolvulaceæ	*Convolvulus hystrix*, Vahl...........	Shibrim
Solanaceæ...	*Solanum retroflexum*................	Anab-ed-dib
do.	*Lycium arabicum*, Schw.	Ausedj
do.	Species of *Hyoscyamus*	Sekkeran
Verbenaceæ.........	*Avicennia officinalis,* L..............	Shora
Labiatæ	*Otostegià Schimperi*, Bth.	Ghassah
Amarantaceæ	*Aerua javanica*, Juss................	Ara
Chenopodiaceæ	*Haloxylon Schweinfurthi*, Aschers....	Rimth
do.	*Anabasis setifera*, Moq.	Hamr
Polygonaceæ	*Calligonum comosum*	Arta
do.	*Rumex vesicarius*, L................	Hamatha
Liliaceæ	*Asphodelus tenuifolius*, Cav.........	Bowrag
Gramineæ	*Panicum turgidum*, Forsk.	Theman

Distribution of Natural Order

NATURAL ORDER	No. of species in Eastern Desert	No. of species in Sinai	Species in Sinai not in E. desert	REMARKS
1. Menispermaceæ ..	1	0	0	
2. Papaveraceæ.....	2	1	1	
3. Fumariaceæ......	1	1	0	Same species in both.
4. Cruciferæ	26	28	8	
5. Capparidaceæ....	6	7	0	
6. Resedaceæ.......	9	8	1	
7. Cistaceæ	4	4	1	
8. Silenaceæ	6	10	7	4 species peculiar to Sinai.
9. Alsineæ.........	3	5	4	3 species of this order appear to be invaders from the north.
10. Paronychiæ	10	11	1	
11. Molluginaceæ ...	2	2	0	Probably same species.
12. Tamariscineæ....	6	4	1	
13. Hypericineæ.....	0	1	1	Species peculiar to Sinai.
14. Malvaceæ	4	7	4	The special species peculiar to Sinai.
15. Fuliaceæ	6	1	1	do.
16. Zygophyllaceæ...	16	14	2	
17. Geraniaceæ......	8	8	0	
18. Rutaceæ	1	1	0	
19. Rhamneæ	2	1	0	
20. Moringeæ	1	1	0	
21. Leguminosæ.....	34	45	11	7 of the special species are described from the Ord. Surv. Coll. and may be synonyms.
22. Rosaceæ	1	5	4	
23. Crassulaceæ	1	1	1	
24. Cucurbitaceæ	2	2	0	
25. Ficoideæ	5	1	0	
26. Umbelliferæ.....	5	6	4	3 species peculiar to Sinai.
27. Rubiaceæ	2	6	4	1 species peculiar to Sinai, the others from the north.
28. Dipsaceæ........	1	3	3	3 species peculiar to Sinaitic peninsula.
29. Compositæ	66	59	15	
30. Campanulaceæ ..	1	1	1	
31. Salvadoraceæ	1	1	0	
32. Asclepiadeæ	5	7	1	
33. Borragineæ	18	21	3	
34. Convolvulaceæ....	5	4	1	
35. Solanaceæ	4	9	2	Seven Sinai species are known from Egypt, 3 being Delta or Mediterranean.
36. Scrophulariaceæ .	7	15	7	This order has a decided North African character in Sinai.
37. Orobanchaceæ ...	3	1	0	
38. Globulariaceæ ...	1	1	0	
39. Verbenaceæ	1	1	0	
40. Labiatæ.........	11	21	12	5 of the special forms are from Ord. Surv. Coll.

DISTRIBUTION OF NATURAL ORDERS—*continued.*

NATURAL ORDER	No. of species in Eastern Desert	No. of species in Sinai	Species in Sinai not in E. desert	REMARKS
41. Plantagineæ.....	8	4	1	
42. Nyctagineæ......	0	2	1	
43. Amarantaceæ.. .	1	1	0	
44. Chenopodiaceæ...	23	19	1	
45. Polygonaceæ	4	3	0	
46. Euphorbiaceæ ...	5	9	2	
47. Urticaceæ	3	3	0	
48. Salicineæ........	0	1	1	
49. Gnetaceæ	2	2	1	
50. Hydrocharitaceæ.	0	1	0	
51. Asparagaceæ	1	1	1	
52. Liliaceæ.........	5	7	3	
53. Colchicaceæ	1	4	4	Chiefly in North Sinai.
54. Juncaceæ	1	3	2	
55. Palmæ..........	1	2	1	*Hyphæne* at Tor only.
56. Naiadaceæ.......	0	5	5	
57. Cyperaceæ	2	3	1	
58. Gramineæ.......	39	40	9	
59. Equisetaceæ.....	0	1	1	
60. Felices..........	1	3	1	
TOTAL....	379	439	135	

CHAPTER V.

ZOOLOGICAL NOTES.

In the account of the Ordnance Survey of the Sinai Peninsula, 1869, p. 253, et seq., Mr. C. W. Wyatt has given a detailed description of the fauna met with in the western half of the peninsula, with which, as will be seen from the subjoined notes, the eastern portion agrees in all essential particulars. These zoological observations are necessarily of a general character, the objects of the expedition and rapidity of traverse being unfavourable to the formation of a systematic collection.

The most important of the Sinai mammalia is undoubtedly the Leopard (*Felis leopardus*)—arab. nimr,—which, though common to both sides of the central chain, is most widely distributed in the eastern ranges near the Gulf of Akaba, where it finds a congenial home in the secluded mountain fastnesses. Being of nocturnal habit, these animals are

seldom seen, though the freshness of their tracks near the camps in Wadi Aad and the Ferani range gave constant evidence of their close proximity. While we were encamped in Wadi Nasb, the destructive character of these animals was well exemplified, five camels having been killed by them in the immediate neighbourhood. On two other occasions Arabs forming part of the expedition observed them in the hills above Wadi Isla, and again in the Ferani range, in both cases at sundown.

No less widely distributed is the *Hyaena striata*, arab. dubha, whose dens are most frequently met with beneath the huge boulders scattered among the low granite hills near the Gulf of Akaba. So far as could be ascertained, foxes and jackals appear to be entirely absent.

The Ibex (*Capra nubiana*) Arab. tetel.—Of all the Mammalia in the Peninsula of Sinai the ibex is undoubtedly the most characteristic, and was the one most frequently met with by the expedition during mountain ascents. They could often be approached at very close quarters, but as a rule when suspecting danger they climb the highest summits, whence they can command the most extensive view of the surrounding country. A prolonged period of rain is unfavourable to the ibex hunter, there being then an ample supply of water in the pools of the highest valleys. On the other hand, during seasons of drought, they descend into the lower valleys (Wadi Nasb, etc.) when they can be more easily approached. These animals were often observed in herds of five to ten, and when feeding it was evident that the females acted as sentinels, the males browsing peacefully till warned of danger by their alert companions.

Dorcas Gazelle, Arab. ghazal.— The general statement made by Wyatt, that these gazelle are never found in the mountains must be some what modified, they having been observed some distance from the plains among the mountains, though as a rule in valleys rich in vegetation, where as many as fifteen have been noted in one herd. It is, however, perfectly true that, unless under stress of circumstances, these graceful animals avoid ascending the hills themselves.

Coney (*Procavia syriaca*) Arab. Wobur.—This animal is common to both Sinai and the Eastern Desert, its occurrence in both localities having been already described by the writer in a former Survey memoir. (See "Topography and Geology of the Eastern Desert of Egypt, Central portion," p. 107).

The Hare.—Arab. arneb, presumably *Lepus sinaiticus*, though not common, was observed on two occasions.

A notable absentee is the Jerboa, but the rodents are represented by Jerbils and a few mice. Wyatt mentions *Gerbillus pyrargus*, Cuv.?

HYENA DEN NEAR WADI KYD

the Lerat *(Myoxus quercinus)*, the Porcupine Mouse *(Acomys dimidiatus.* Rüpp.), *Acomys russatus*, Wagn., and *Acomys cahirrhius*, Geoffr.

Birds.—One of the commonest of the birds observed soaring above the mountain crests was the Egyptian vulture, *(Neophron percnopterus*, Linn.) which served on many an occasion as a useful guide, its flight above the ridge indicating from a distance the presence of the members of the main party, even though these were themselves invisible to the observer in the valley below or on some neighbouring crest. Eagles are probably also present in the same valleys, especially near Gebel Tha'albi, but as none were actually shot, their occurrence is not absolutely proved. Wyatt states that these birds are rare in the peninsula, but Barron noted them in numbers on one occasion, when a leopard had killed both a camel and eagle.

In Wadi Letih, a small owl (probably *Athene meridionalis*, Risso) was observed, which drew the remark from one of our guides "that it was a bird of ill omen, having an evil eye, and if it should flutter behind the head of a man during his sleep, from that day forward misfortune and illness would continually attend him." Wyatt records the presence of the Common Cuckoo *(Cuculus canorus*, Linn.), and the European Bee-eater *(Merops apiaster*, Linn.) from Wadi el Hudera and El Noweiba respectively, but regards them as being mainly birds of passage. The Common Swallow *(Hirundo rustica)* was observed at the latter locality early in April, evidently migrating.

Of the smaller birds, the Chats (*Saxicolas*) with their black and white plumage, are both the most striking and most frequent visitors to the camp, their song also being very melodious. The White Wagtail *(Motacilla alba*, Linn.) showed its friendly disposition by its frequent visits, even entering the tents, and its presence was always welcome in a land where, in general, life is so conspicuously absent.

The Larks are also probably as frequent as in the eastern desert, but the fact that they appeared as customary objects in the landscape rendered them less noticeable than some of the rarer but more striking species.

Among the common birds is a species of Crow, which was often seen perched on the backs of the camels while these were feeding, and the Raven (*Corvus umbrinus*)—arab. ghorab.,—which was especially noticeable in the granite crags above Wadi Nasb.

Of the game birds the most frequent and most welcome to the traveller as supplying an addition to his commissariat is the Hey's

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Partridge, which, with its neutral protective colouring, is difficult to distinguish as it runs rapidly along the rocky slopes which bound the valleys. Of the migrating birds, the only one observed was a Crane-like species which crossed the peninsula during the spring months in enormous numbers, often flying at great heights. Their direction of flight was mainly from west to east, confirming the statement on p. 110, "Eastern Desert Survey Report," where reference is made to the passage of the Red Sea from Gharib to the Sinai coast north of Tor by large flocks of these birds, similar flights being observed near Ain el Hudera in May. Two birds are mentioned in the Ordnance Survey report, as having this habit, viz.: the Common Crane (*Grus cinerea*, Bechst.), and White Stork (*Ciconia alba*, Bechst.), Although not near enough to be recognised, from their appearance and manner of flight these were most probably the first-named species. The vertebrate fauna of the eastern side of the peninsula seems, indeed, to be of a very limited description, and so far as could be judged its other members (*Reptilia*, etc.) do not differ very materially from those already mentioned in the Eastern Desert Report. Lizards were everywhere abundant in those valleys where bush life was at all common, and snakes, especially one of the hornless flat-headed *Cerastes*, became increasingly frequent as the spring advanced, while a thin whip-like species was generally present in the water-holes.

But all observations made point to one conclusion already emphasized by the writer in the Eastern Desert Memoir, viz: that both as regards their flora and fauna (whether vertebrate or invertebrate) the Eastern Desert of Egypt and the Peninsula of Sinai form part of one life province, differing only in a few details (See table on p. 108, "Eastern Desert Report.")

Turning to the separate orders and sub-orders of Invertebrata, the following observations of a general character may be of interest to future travellers.

Of the Arachnida, the Acarine (Mites) are very prominently represented by the camel-tick, which infests the main tracks, and by its parasitic habits is troublesome alike to man and camel. Owing to some unknown cause, which leads the Arabs to throw them away instead of killing them after removal from the camels, they are in great numbers, no less than fifteen having on one occasion been noted in one spot.

Their persistence in tracking their victims is remarkable, and it was often amusing to let them approach, and then lightly stepping over them, to watch the puzzled halt to which they were suddenly brought, the advance being again renewed on rediscovering the object of their

attack. While true spiders and scorpions appear to be rare, only one of the latter having been observed at the head of Um Shoka, the Solifugæ, or false spiders, (especially *Galeodes*, which attains a large size) are numerous. These being of nocturnal habit were often seen after sunset running about the tents with great rapidity. Although in the Sudan the Arabs consider their bite to be poisonous, this opinion is not shared by those in Sinai. Turning to the orders of the Insecta, the Orthoptera are especially represented by the carnivorous Mantidæ, or leafinsects, of which three species have been noted in Sinai.

One of these is the conspicuous form whose bright-green elytrae exactly resemble the leaves of trees, another has a very thin body like a twig, while the third is shorter and thicker, in colour remarkably akin to its habitat the desert, and probably an *Eremiophilas*. The latter is invariably found in the coral reef area, which is almost destitute of vegetation. The Orthoptera Saltatoria are very prominently represented by a large species of locust, which flew in and over the mountain valleys in considerable numbers, their wings shimmering, delicately iridescent, in the sunlight. Their distribution was no doubt to a large extent dependent on the prevailing north-east wind, which tended to drive them towards the centre of the peninsula. May-flies (*Ephemeridæ*) and the Dragon-flies (*Libellulidæ*) are most noticeable, the latter being especially prominent round the shallow pools in the larger valleys. The Rhynchota are represented by a *Cicada*, which in the spring is very abundant in the tamarisk trees, on whose young shoots it feeds. Its puncture causes a sweet gum to exude, which on hardening forms the "man" of the Arabs.

The more familiar members of the Diptera, viz: flies, fleas, and mosquitoes were not much in evidence in the mountains, this being probably due to the expedition having been undertaken in the main during the winter months; in the plains both flies and mosquitoes are apt to be a source of annoyance. Lepidoptera (Butterflies and Moths) are represented, but as in the Eastern Desert, they are not numerous, and though collections made at certain spots might be rich in individual specimens, the number of species would probably be few.

The Coleoptera of the Ordnance Survey have been examined by G. R. Crotch, who gives a list of 128 species taken by Mr. Palmer, 15 being described as new. "Of these, 26 appear to be peculiar to the district, while only 10 are common to Europe generally, 20 are found all along the borders of the Mediterranean, while the remainder are confined to Syria and Egypt.

Hemprich and Ehrenberg appear to have been the first to have made any systematic collection in the district, the species obtained by them being now in the Berlin Museum. Crotch states that "the most marked group is perhaps that of the Hydradephaga, where all the species appear to be peculiar. The extreme isolation of the scanty water supplies may perhaps account in some degree for this. The comparatively large proportion of the coprophagous species (in the list) is no doubt to be explained by the universality of their pabulum, and by the little search requisite for them. Next to these, or even more numerous, are the Tenebrionidæ, which at once mark out the desert character of the fauna, especially when contrasted with the almost utter absence of the Phytophaga. It is in the Tenebrionidæ that I have found the greatest number of new species, some of which are of extreme interest. The little genus of nocturnal Lamellicornes, *Pachydema*, also would seem to be probably rich in species in the desert, for the four described are all very closely allied to *P. Saulcyi*, Reiche, though abundantly distinct from it." Reference is also made to the magnificent series of 170,000 specimens collected by M. Ch. Piochard de la Brûlerie in Syria and Palestine.*

The most prominent of the Hymenoptera are the hornets and ants, the former being especially abundant on a markh bush in Wadi Gnai, while the latter are ubiquitous in their distribution. The traveller in Sinai, if sleeping on the ground, is liable to much annoyance from these insects, which in serried masses invade the tents; on one occasion they could only be stopped by digging trenches, and burying the invaders as they advanced, and on another a long unbroken band of these insects was observed stretching across the broad valley of Sa'al.

CHAPTER VI.

ECONOMIC NOTES.

A very deep interest has been evident during the last few years in the revival of the ancient mining industry which formerly existed in the Eastern Desert of Egypt, and although during the preliminary studies in Eastern Sinai no actual gold mines have been discovered, the occurrence of ancient copper workings at widely separated localities

* A valuable collection of insects has recently been made by Herr Guyot, but the results have not yet been fully worked out.

and the similarity which exists between the rocks of Sinai and the Egyptian Desert, warrant the assumption that gold may also be found in the peninsula.

In Egypt proper between the 22nd and 28th parallels of north latitude *Gold* is now known to be widely distributed in both the older sedimentary and plutonic rocks, and more especially in the neighbourhood of, or actually in the less acid granites (hornblende-granites), quartz-diorites, and diorites which often appear to form well-defined zones, near the junction of the granites with the ancient sedimentaries. As rocks of the last-named type are largely developed in Eastern Sinai, (see appended maps), it is hoped that a record of their distribution may prove of material aid to the prospector.

In many cases despite the large number of ancient workings, it has been most difficult to obtain even traces of *Gold* at the surface, but deeper excavations have led to the finding of rich ore bodies in some of the Egyptian mines. The want of superficial deposits is largely accounted for by the removal of the outcrops and weathered portions of auriferous bodies by the ancients, and in any case patient search and study of the various formations has been necessary to locate the old shutes; such work does not come within the functions of a rapid geological survey, whose object must be to lay a wide general foundation on which more detailed research may be based.

Summarizing with regard to the occurrence of gold in Sinai it may be stated :—

1. That the similarity of the formations to those of the Eastern Deserts of Egypt is a hopeful indication that auriferous deposits will occur.

2. Only a systematic search by prospectors can prove the existence or non-existence of gold.

3. In concluding this note on gold the quartz region near the foot of Gebel Abu Mesud may be indicated as one of the most likely spots at which to commence such an exploration.

From time to time expeditions have been made by various exploring parties into the Sinai Peninsula, but unfortunately but little of their data has been published.

The following lines are inserted here to draw attention to a few facts or statements which have been made by these explorers; the opinions expressed have been more or less indefinite, and are therefore excluded from this Report. Some of the verbal information which has been given to the writer from time to time leads him to suppose that there

exist many ancient mining centres for copper, but without having had an opportunity to corroborate such evidence, it is scarcely within his competence to insert the same here.

Referring to the analysis of samples included in this Report, it must be noted that these are merely surface specimens broken off from formations noticed during a rapid reconnaisance survey, and are not intended to indicate the relative values of such, but the analyses warrant the hope that there may be extensive formations which, under suitable conditions, may prove of commercial value and at least are interesting as proving that various mineral products do exist in the Sinai Peninsula.

Copper.—Whereas the probability of the discovery of gold can only be inferred, ores of *Copper* are certainly present, not only on the western, but also on the eastern side of the peninsula. This is notably the case in the neighbourhood of the plain of Senned, near Wadi Khosh Dhaba, where workings were discovered by Mr. Holland in 1868 (position shown on Ordnance Survey map). He states (p. 224 of the Ordnance Survey Report), that "my attention was attracted by numerous small pieces of blue carbonate of copper which had evidently been brought there. I traced them up to the foot of a rock, and finding that they ceased, I dug a hole there, and came upon a slag heap and broken twyers exactly similar to those found at Wady Nasb. My Arab, Salem, then told me that he could take me to the place where the blue stones came from, and he conducted me to a dyke which had been excavated more or less for a distance of nearly two miles, and which was exceedingly rich in the blue carbonate. The circumstance of this dyke occurring in the syenite renders it probable that the ore smelted at the other places named was found in the same rock."

Holland also made an interesting discovery "in a curious way in 1868, on the coast of the Gulf of Akaba, almost opposite the island of Tiran. As I was walking down the coast and crossing a watercourse I picked up two flakes of flint. This led me to trace up the watercourse to a low hill, on which I found several heaps of slag and other flints. There was also a good deal of copper here. A little north of Sherm I once found several pieces of carbonate of copper in a wady bed, but was not able to follow it up. It is possible that the ore came from there."

The writer of this memoir had a similar experience, finding numerous pieces of copper slag on a raised coral reef near the sea a little south of Nebk, an occurrence which led to this mineral being kept

specially in view during this portion of the work, and to the general conclusion that copper ores were present in the hills to the west of the plain between Nebk and Sherm.

Near Nebk in the Wadi Samra a syndicate did for a time conduct prospecting operations, but these have since been abandoned. Some specimens of silicate of copper coming from this spot are exhibited in the Geological Museum of Cairo.

The above are the two regions in Eastern Sinai where copper ores have been recorded, but those on the western side have attracted most attention, both in ancient and modern times. Visited by Rüppell,* in 1822, on behalf of Mehemet Ali Pasha, he located them near Wadi Nasb, in lat. 29° 8′ north and 50° 55′ E. long. Here enormous workings were found in the sandstone, and a sample smelted yielded 18 per cent. of pure copper, the same amount being found in the ferruginous slag produced, while a garlic odour emitted during the operation suggested the presence of arsenical compounds.

Rüssegger,† when passing this locality in 1838, was not aware of the existence of copper ores, but discovered the presence of iron and manganese deposits in the sandstone, which had obviously been worked in ancient times.

In 1845 Lepsius found copper-bearing sandstone and fragments of copper at Bir Nasb, but was unable to trace the workings described by Rüppell.

The general results obtained were analyzed by Dr. Fr. Gensler,‡ who concluded:—

1. The minerals of economic value in Sinai were copper, iron and manganese ores, speissglanz, and turquoise.

2. Only the copper ores could be regarded as of considerable, in fact of uncommon development (in beträchtlicher, ja in ungewöhnlich grosser Mächtigkeit kommen dort *nur* Kupfererzlager vor). In Wadi Nasb these are visible, and their presence in Wadi Maghara may be inferred in view of the specimens obtained by Lepsius.

From the archæological study of the famous inscriptions at Sarabit el Khadim it is highly probable that the word "Mafkat," therein so frequently repeated refers to copper, and that the Egyptians had made this metal the main object of their research. It is of deep interest to notice that while Mafkat is the only mineral described in an inscription

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* RÜPPELL: "Reise in Nubien, etc." p. 264, 1822.

† RÜSSEGGER, "Reise in Unterägypten, auf dem Halbinsel Sinai, &c." p. 225, &c.

‡ "Zeitschrift für Aegyptische Sprache" Oct., Nov. 1870, p. 137-150.

of Amenemhat III.* at Sarabit el Khadim, in another of Rameses III.† enumerating the products of the land of Punt or Arabia Petræa, Mafkat is omitted, only *Rami anta* (gum) and *jut* (wood) being mentioned. It is also noticeable that the last record on the plateau of Sarabit el Khadim dates from the reign of the last king of the 19th dynasty, while ‡ the 20th begins with Rameses III; it therefore appears probable that this warlike monarch abandoned the mines owing to increasing difficulties in connection with fuel, obtaining his supplies from other sources. The general discussion as to the reasons why Mafkat should be regarded as pure copper will be found in Dr. Gensler's paper above-mentioned.

Holland (loc. cit. p. 224) has suggested that this copper-ore may have been used solely for producing the beautiful blue glazes of the Egyptian ware, but the importance of "Mafkat" in the inscriptions, where it takes fourth place in the lists of minerals given, being only preceded by gold, silver, and "chebset," points rather to actual metallic copper having been the quest. Other localities for copper slag have been noted by Holland, and in 1898-99 the district was re-visited by Barron, of the Geological Survey of Egypt, who has dealt with this question in his memoir on Western Sinai.

It will be seen from the above remarks that copper ores play an important part in Sinai, and are more especially developed at three points:—

1. In the neighbourhood of the northern Wadi Nasb.
2. Near the plain of Senned.
3. In the hills west of the Nebk-Sherm plain.

Manganese.—In addition to the copper ores, Sinai is known to contain those of iron and manganese, these being especially developed on the western side of Sinai, where they have been studied by Barron. The analyses of the samples collected by him from Wadis Malha and Hallig (see attached list) show manganese ores with over 60 per cent. of manganese. On the eastern side no such percentages have been obtained, though one of the occurrences is of considerable interest. As remarked elsewhere, the cliffs at Sherm are remarkable for their peculiar colouring, and an examination showed that they were composed of pebbles cemented by the hydrated oxide of manganese,

* Lepsius, "Denkmaler II." 144 q. lin. 7.
† Lepsius, "Denkmaler III." 210. a.
‡ Lepsius. "Briefe aus Aegypten," p. 537.

psilomelane. Of this deposit typical samples have been analyzed by Lucas with the following results:

I. Manganiferous gravel from summit of cliff above Sherm.

II. Ferruginous bed, base of manganiferous gravel, Sherm.

	I.	II.
	%	%
Silica and insoluble	54·78	70·10
Iron and aluminium oxides	2·32	12·92
Manganese dioxide	30·33*	12·67
Lime	trace	trace
Magnesia	nil	trace
Loss on Ignition	9·48	5·06
	96·91	100·75

In view of the frequent presence of *Cobalt* in association with psilomelane, the former was specially sought for, but proved to be entirely absent.

This manganiferous deposit caps the cliff which borders the southern end of Sherm harbour and the large bay to the south; it probably has a certain extension inland, naturally suggesting the presence of some rich manganese-bearing area, now hidden under the granite detritus which covers the plateau west of Sherm. The flying traverses taken across the plateau failed to locate such beds *in situ*.

When ascending Gebel Ashara, psilomelane was obtained in a vein traversing the granite, the analysis yielding the following result:—

	%
Silica and insoluble	40·42
Iron and aluminium oxides	4·92
Manganese dioxide	50·04
Lime	trace.
Magnesia	"
Loss on Ignition	9·46
	104·84 †

It may therefore be generally stated:—

1° Manganese dioxide is present in the granite of the Sinai region.

2° By concentration it has given rise to deposits rich in the oxides, two districts being especially conspicuous:—

(*a*) In Western Sinai, in Wadis Malha and Hallig, where, as shown by Barron, rich ores are present near the junction of the Carboniferous limestone and sandstone, largely existing as pockets.

* Manganese 19·16 %.

† Lucas notes that a small part of the manganese evidently exists in a lower state of oxidation than the dioxide, thus accounting for the percentage result.

(*b*) In Eastern Sinai, at Sherm, where hydrated manganese oxide forms the cementing material of the gravels. Owing to the high percentage of silica (quartz) as sand, concentration would probably considerably enrich the product.

Iron.—In intimate association with the manganese ores of Western Sinai are iron ores, samples of which show high percentages, and include both the kidney and the micaceous varieties. Whereas in Wadis Malha and the northern Nasb and its neighbourhood, these ores occur, as above stated, near the junction of the Carboniferous limestone and sandstone, in Eastern Sinai they are present in the quartz veins which seam the granite near the foot of Gebel Abu Mesud, being there mainly in the form of micaceous hæmatite. The samples collected at this spot yielded the following analyses.

I. Magnetite from Wady Um Agraf:

	%
Silica and insoluble	3·42
Oxide of iron	96·25=67·37 % iron
Oxide of aluminium	trace.
Lime	,,
Magnesia	,,
	99·67

II. Hæmatite in quartz vein, Wadi Um Agraf:

	%
Silica and insoluble	40·77
Iron and aluminium oxides	59·25
Lime	nil.
Magnesia	trace.
Loss on Ignition	0·59
	100.61

III. Limonite in quartz vein, Wadi Um Agraf:

	%
Silica and insoluble	4·90
Oxide of iron	92·20
Oxide of aluminium	trace.
Lime	,,
Magnesia	,,
Loss on Ignition	2·82
	99·92

There are therefore two regions in Sinai where iron ores have been shown to be present:—

1. In Western Sinai, in the neighbourhood of the northern Wadi Nasb, at the junction of the Carboniferous limestone and sandstone.

2. In Eastern Sinai in the region to the west of Gebel Abu Mesud, where they are present in quartz veins seaming the granite.

Turquoise.—In crossing the Nubian sandstone country this mineral was sought for without success, the only record in Sinai being therefore its occurrence at Gebel Maghara and Serabit el Khadim, both on the western side.

Phosphates.—The horizon at which phosphates are known to exist crosses Eastern Sinai far north of Noweiba, and thus is outside the area studied by the Survey.

ANALYSES OF IRON AND MANGANESE ORES OF SINAI.†

(By A. Lucas, at the Survey Department Laboratory.)

No.	Museum No.	Fe_2O_3	Fe	Mn O	MnO_2	Mn	LOCALITY AND REMARKS
1	5000	69·34	48·54	..	3·06	1·94	Old Mines, Wadi Hallig.
2	5001	16·90	11·83	32·87	18·56	37·18	do.
3	5002	98·24	68·77	..	..	..	do.
4	5003	93·69	65·58	..	..	..	do.
5	5004	73·62	51·53	..	9·58	6·05	do.
6	5005	38·80	27·16	14·72	24·10	26·64	do.
7	5006	25·86	18·10	..	..	..	do.
8	3947	46·96	32·87	..	..	..	Wadi Malha (Carboniferous sandstone). Gangue practically all silica.
9	4036	34·24	23·97	..	29·52	18·66	Mouth of W. Hallig. SiO_2=1·3 $CaCO_3$=16·7. Water 13·21.
10	4215	2·32	1·62	..	30·33	19·16	Summit of cliff above Sherm Bay. SiO_2 and Insol.= 54·7. Water 9·5.
11	3911	3·74	2·62	15·21	71·59	57·00	Wadi Malha.
12	3971*a*	32·10	22·47	..	..	..	Wadi Hallig.
13	3971*a*	27·60	19·32	14·60	40·81	37·03	do.
14	3970*c*	..	..	..	71·41	45·10	do.
15	3970*b*	20·44	14·31	..	39·95	25·23	do.
16	3970*a*	..	..	41·03	45·50	60·48	do.
17	3970	25·34	17·74	..	38·19	24·12	do.
18	4819	* 4·92	..	..	50·04†	..	Summit of Gebel Ashara. SiO_2 & Insol. 40·42. Water 9·46.
19	7798	96·25	67·37	..	..	..	Magnetite on Um Agraf pass. SiO_2 and Insol. 3·42.
20	4875	*59·25	..	..	..	..	Hæmatite, Um Agraf. Silica and Insol. 40·77.
21	4817	92·20	..	..	..	..	Quartz Reef. Um Agraf. Silica and Insol. 4.90.
22	4884	*12·92	..	..	12·67	..	Base of manganese bed, Sherm. SiO_2 and Insol.=70·10, combined Water=5·06.

* Includes a little aluminium oxide.

† A small part of the manganese evidently exists in a lower state of oxidation than the dioxide.

N.B.—Nos 1-9 and 11-17 collected by Barron; the remainder by the writer.

Water supply.—The rainfall in Sinai being more abundant than that of the Eastern Desert, the water question here is of minor importance, those exploring the region readily obtaining supplies in the granite hills or from the three well-known wells at Dahab, Sherm, and Nebk. Similarly for expeditions in the northern part of this area the oases at El Ain and Ain El Hudera supply excellent drinking water from perennial fault-springs.

In addition to the rock-pools in the granite, shallow diggings or wells in the larger valleys usually yield good results, and on the seashore there seems to be a tendency for the underground water to be ponded back at the point where the large drainage lines enter the sea. There are actual surface streams in Wadis Isla, Nasb, Kyd, and Hebran, springs in the oases already mentioned, wells at Noweiba, Dahab, Nebk, and Sherm, and should the last-named be dry, an exceptionally well-protected water-supply exists at the head of Wadi Aad. If information as to further details be required, it will be found by referring to "Waterpools" in the index.

The chief water difficulty arises in visiting the barren schistose district between Dahab and Nebk, the sandstone region south of Ain el Hudera, and the sand-swept area near Ras Mohammed.

Sands.— In most civilized countries the pure white sands of the Upper Nubian sandstone, which are sometimes over 100 metres thick, would be of value in connection with glass manufacture, but in view of their isolated position, are of no importance from a practical point of view.

Building stones.—The same statement holds good for the exploitation of building stones, there being an inexhaustible supply of granites, felsites, and gneisses, and some of them, like the delicate gneiss of Gebel Heyala, are very beautiful. On the other hand some highly characteristic rocks of the eastern desert of Egypt, notably the imperial porphyry, have not up to the present been recorded from Sinai.

Gum.—Gum appears formerly to have been an important product of Sinai, but has ceased to be so owing to the wholesale destruction of the gum-bearing acacias for the manufacture of charcoal, these trees being only now present in small numbers at the foot of the granite hills or in the main valleys. In view of the large supply of this product from the Sudan, it is very unlikely that even extended replanting would yield any results of economic value.

The plants yielding colocynth and senna, though present in the peninsula, do not appear to be used by the Arabs. The palm-groves are of local importance, those of Dahab being of exceptional size. The writer can see no reason why planting on the seashore at the mouth of Wadi Kyd should not add a grove of some size to those already in existence, if the inference as to the ponding back of the water at the seashore rests on a sound basis.

Summary.—From the above it will be seen that Eastern Sinai possesses *copper*, *manganese* and *iron* ores, the possibility of *gold* being present also not being excluded by its geological structure.

Coal.—A prospecting party working in Eastern Sinai to the north of the region examined by the survey has discovered a vein of bituminous coal in a formation whose age is as yet undetermined. The analysis by Mr. Lucas gives:

		%
	Moisture.................	2·74
Combustible substances..	Volatile Matter...........	36·59
	Coke.....................	34.94
	Ash......................	25.73
		100.00

II.—GEOLOGY.

Speaking in the broadest sense, the geological structure of Eastern Sinai is comparatively simple, the hill districts of the southern portion being entirely composed of igneous and metamorphic rocks; north of Wadi Nasb these are capped by Nubian sandstone, which itself is overlaid by limestones of Cenomanian age. Owing to faulting and rift formation, this simple succession is, however, considerably disturbed, the result being the production of extremely complex topographical conditions. The most important feature outside the hill-region is the plain between Nebk and Sherm, in which, in addition to the superficial gravel deposits and coral reef, are some important strata of Miocene age. In addition, a large number of interesting beds of gravel occur in the mountain valleys.

The geology will be treated under the following heads;

Chapter VIII.—Pebble gravels, travertine, etc.
„ IX.—Coral-reefs.
„ X.—Miocene strata.
„ XI.—Cretaceous limestones of Cenomanian age and Nubian sandstone.
„ XII.—Igneous rocks.
„ XIII —Ancient sedimentaries and contact changes.

CHAPTER VII.

PEBBLE GRAVELS, TRAVERTINE, ETC.

A.—PEBBLE GRAVELS AND TRAVERTINE.

Nothing will strike the observant traveller more forcibly on entering the narrow gorges in the Sinai hills than the great development of terraces of gravel in the principal valleys, these being often over 20 metres in height, and composed either of materials of different consistency very roughly stratified, or still more often of the debris of

the igneous hills mixed together in a more or less chaotic manner. Fraas was especially impressed by these occurrences, which he could only presume were the moraines left by former glaciers (though as to their age he could say nothing), an idea which is not really so far-fetched as might appear, as even at the present time snow lingers on the summits of the Sinai hills, sometimes for days together. Thus in December 1898, when we ascended Gebel Sabbagh, it was covered with a coating of snow which had not disappeared after several days of sunshine, the temperature at the summit at midday barely exceeding 0° Centigrade. If the temperature here were reduced to the same extent as it would be in Europe during the Glacial Period, a small amount of névé would have accumulated in the higher mountains, and the increased torrent-action resulting therefrom might well have been a factor in the formation of these deposits.

When Wadi Isla leaves the hills and enters the plain of El Qa'a it is continued for a short distance between cliffs of boulders 10 metres high, clearly showing that denudation now exceeds deposition, and indirectly proving that the area had undergone elevation. At points where the valley expands, or near the entry of side-valleys, as opposite Wadi Emlaha, the same cliffs of pebble-gravels are present, generally cut back into a vertical precipice consisting of boulders of the igneous rocks of the district of the most varied forms and sizes. These gravels extend far over the plain of El Qa'a towards Tor, where they are found capping the salty marls and gypseous limestones at El Wadi near that town.

Wadi Nasb.—These beds again reappear on the other side of the watershed in Wadi Nasb and its tributaries, being especially noticeable up Wadi Hezaima and where Wadi Harban enters the Nasb defile, at the latter point being at least 30 metres high, and crowned with remains of ancient buildings.

Um Girhat terraces.—At the end of the first Nasb ravine, where it is crossed by the Um Girhat-Rachal rift, the terraces again form a low plateau on the northern side, serving as an excellent camping-ground, and are also well developed between the drainage lines of Wadis Kherait and Matershat which cut obliquely across the Um Girhat depression.

Wadi Hamra.—While the main gorge of Wadi Nasb contains but little trace of their existence, they are again prominent in the hill-districts to the south, as in Wadi Hamra at the base of Gebel Ashara.

Other points in the mountains at which important terraces of these gravels occur (which also form good camping grounds) are the following: at the junction of the Wadis Ethmoi and Kyd, the gravels lying in the angle between these two valleys; at the foot of Gebel Gazala, where Wadi El Ghim joins Kyd, and also to the west of this point, bounding Wadi Kyd itself; at the junction of Wadis Marua and Humr, and especially well marked at the base of the higher ranges in Wadi Ethmoi. On issuing into the sea-coast plain north of Nebk, these beds are found overlying coral limestone at Ras Atantur, rounded pieces of granite and schist being also mixed with the Astræan corals, *Laganum*, *Tridacna*, etc., which form the summit of the reef. These gravels, which from this locality dip gently to the south-west and occupy the plain region up to the foot of the hills, are consequently not earlier than Pleistocene in age.

Terraces at mouth of Wadi Kyd.—At the mouth of Wadi Kyd are two remarkable flat-topped terraces at levels of 23 metres and 31 metres respectively, and also traces of a third at a still greater elevation are visible. These consist of a thin deposit of pebbles and boulders (many of which are over a metre in diameter) lying on the older rocks; those of granitic origin rest mainly on the slopes, while the dark basic rocks are spread on their upper surfaces. It seems difficult to account for these characteristics except on the assumption that they are in reality a series of raised beaches, whose presence at these levels suggests recent elevation of the whole district.

Higher up Wadi Kyd there is a gravel ridge stretching halfway across the valley at a point where El Beda joins it from the west, Wadi Kyd forming two branches which pass round it and reunite on the southern side. Similar terraces are met with in the higher valleys to the south, notably at the head of Wadis Yahamed, Sabbagh, Um Adowi, and forming the Jeraif plateau, while in many of the side-valleys (Um Ekhlis, etc.) they are also present.

Sufficient has been said to show that these beds occur practically throughout the igneous hill region, especially at the heads of the main valleys and their junction with the minor tributaries. These are probably not older than the Pleistocene, as they overlie coral reef containing Pleistocene shells, and are characterized by the fact that they contain fragments of all shapes and sizes derived from the surrounding hills, which are imbedded in a sandy matrix consisting of material of the same derivation, the source being thus strictly local.

GRAVEL TERRACE AT MOUTH OF WADI BUDR.

With regard to the question of their origin, it is only possible to suggest considerations, the theory which commends itself to the writer involving a combination of two circumstances, viz., the earth movements of which the region shows such abundant evidence, and a great rainfall.

The earth-movements might very readily have resulted in temporary ponding back of the mountain torrents, when it is recalled that the greater part of South-eastern Sinai is even now almost a closed system, bounded on three sides by mountainous watersheds, only one of which is broken through by two valleys. With regard to the question of greater rainfall, it need only be noted that at the present day the storms, though frequent in winter, are of short duration, and the resulting torrents are active in the work of erosion rather than of deposition, these being chiefly engaged in filling the smaller valleys with confused masses of huge boulders, such as will be familiar to every traveller who has climbed the mountains of the peninsula.

But one of the most striking features connected with these gravel plateaux is the perfectly flat nature of their upper surface even in the upland wadis, a character quite inconsistent with their having been produced by rushing torrents, but in accordance with the hypothesis of their formation in ponded-back lakes or marine fjords. The apparent absence of any marine shells renders it probable that the detrital beds of the central portion of Sinai are due to deposition of the material derived from the surrounding hills in lakes, rather than to their accumulation in arms of the sea. Whatever theory may finally gain acceptance must take account of their extensive distribution, and the height at which they are now found, they sometimes being 1200 metres above sea-level.

B.—Manganiferous Pebble Gravels.

While the majority of the bays of the Akaba coast are broad inlets of the sea, running into the land between the yellowish-white limestone cliffs of the raised coral series, Sherm is at once distinguished by the red and black colouring of the scarp commanding the bay to the west and south. This exceptional appearance is due to the presence of a conglomerate, whose constituents are *cemented by the hydrous black oxide of manganese*, psilomelane, in places as much as four metres thick, while underneath are beds coloured red by ferruginous ochre. These gravels are closely connected with a core of red granite, stopping abruptly where the latter is no longer exposed at the surface to the north with the result that the northern cliff is of a totally different

character, consisting of coral-reef forming a cap to sand-rock of varied tints. The manganiferous gravels only seem to be connected with and overlie the granite at the point where the latter faces the sea, extending but a short distance up the valleys and not being found south of the transverse chain of Zafara, which rises abruptly from the plain. This hill, consisting of sand-rock mainly derived from granite associated with massive beds of sandy limestone, presents a difficult geological problem, owing to the absence of fossils by which its age might be determined. Although the manganese beds are closely associated with the granite, and possibly owe their origin to the re-arrangement of Nubian ferruginous sands immediately overlying the latter, direct proof in favour of this hypothesis is wanting, though sands of presumably Nubian age form the base of the northern cliffs of Sherm bay. It is also interesting to note that the Austrian S.S. "Pola" expedition found manganiferous deposits forming on the floor of the Gulf of Akaba itself, the presence of these manganiferous beds suggesting the occurrence of important manganese deposits west of Sherm, but our studies in that region have not brought such to light, and the gravel bed may be the result of their complete denudation.

C.—Oolitic Valley Deposits.

Walther (*Die Korallenriffe der Sinai Halbinsel*, Bd. XIV. Abhandl. math.-phys. Königl. Sächs. *Gesellschaft des Wissenschaften*, pp. 481-484,) calls attention to the fact that near Suez and especially on the border of the Kyd desert he found oolitic grains, while he had nowhere noted oolitic rocks either in Sinai or in the Arabian desert. From his examination he concludes that these grains met with especially at the mouth of Wadi Dehese are really a recent formation in *statu nascendi*. A closer examination showed him that these consisted of quartz-grains enclosed in a calcareous layer, and that when several zones were present there was a darker band between the inner dark-yellow and outer clear shell of calcite. Amongst the minerals noted as nuclei were felspar, garnet, magnetite, and fragments of foraminifera. His conclusion is that the mineral grains come from the desert and have been carried by land-winds into the shallow sea, where various small animals would play their part in assisting the formation of the calcareous coatings. These interesting observations can now be extended, as an oolitic rock of this very nature is most extensively developed among the hills north of Ras Mohammed, where it forms a striking light-coloured oolitic calcareous sandstone bounding Wadi

Hashubi, and almost filling the small tributary valleys, which are reduced in many cases to narrow cañon-like ravines. Walther has mapped this as Dünensandstein of Hashubi. As it is the most striking deposit in this neighbourhood, it naturally attracted special notice, and it may be therefore interesting to give the notes as they were made on the ground, stating first that these were written without knowledge of Walther's result, his paper being at the time with the party working in West Sinai. The facts noted in connection with it are:

1. The sand-rock consists of quartz and orthoclase grains similar to those of the wind-blown sand in the neighbourhood cemented by carbonate of lime, which in many places surrounds them in a series of calcareous coats. 2. These strata dip in every direction, being often plastered against the sides of the hills, or forming horizontal beds cut down vertically in the gullies. Further, the sandstone forms the sides of Wadi Hashubi and every one of its tributary valleys, the ridges of moderately coarse biotite-granite underlying it, or dykes of dolerite rising through it like islands. In this area the sandstone varies in dip from horizontal to about 5° and *shows* in places *traces* of *ripple-marking* and *very fine sun-cracks*, numerous long tubular cavities, and somewhat questionable rain-prints, showing maximum depression towards the south. The sandrock has covered the ridge running south of Wadi Hashubi, and near its summit shows a remarkable fault-like structure, beds dipping 25° S. resting against horizontal strata, and being due probably to local slipping. In the lower part of Wadi Hashubi it is very thick and horizontal, in some places being strongly current-bedded and containing lenticular masses of pebbles. The dip it shows when overlying the surface of the igneous rock is probably due to slipping of once horizontal beds worn away below, and the sandrock has a peculiar habit of weathering internally, a thin external wall pierced by small holes masking a larger internal cavity. Here well-defined pebble beds overlie this formation, which itself rests on a floor of granite.

Similar strata were found to be present in the small side-valleys of the lower igneous hills to the north of Hashubi, the main valleys being filled with long ridges of the igneous gravels. In a groove at the foot of Gebel Hedemia the sandrock forms cliffs about 10 metres high, but is coarser in its composition than that of Hashubi, some of the contained pebbles of granite being over ½ metre long. This sandstone also occurs on the pass between Hedemia and Abuzag, the altitude of which by aneroid was 696 metres above sea-level. At the head of the valley running from this point, the cañon-structure is strikingly displayed, these light-coloured beds forming almost vertical battlemented walls

(about 45 metres high), overhanging a sandy plateau, which is again cut into by deep, narrow, winding ravines, themselves carried down deeply into the underlying granite. Under Abuzag the terraces appear horizontal, but there is some local variation in dip, probably due to slipping. These upper beds contain a few large boulders, (one about 60 cm. by 43 cm.), but usually the detrital material does not exceed 6 mm. The larger boulders in places give rise to well-developed but small earth-pillars. Further north, in the upper part of Wadi Awaja, the sandrock becomes more and more filled with detrital matter, coarser and finer layers alternating in the side-valleys. On crossing the northern pass of Wadi Awaja, the calcareous sandstones disappear, their place being taken by typical boulder terraces of the ordinary type, forming walls in places over 15 metres high and close to the pass containing boulders up to 60 cm. in diameter, but increasing in size towards the lower part of the valley.

The origin of this remarkable deposit is undoubtedly difficult to explain, the natural view that it is of marine derivation not being absolutely confirmed by the discovery of any marine organisms. Nevertheless the results obtained by Walther are in favour of this hypothesis, which would demand a differential movement of no less than 700 metres in the southern end of the peninsula during comparatively recent times, a result which, however startling, is in accordance with other evidence from neighbouring regions.

D.—Gravels cemented by Calcite.

While in the Dahab peninsula the surface is formed by low ridges (2 metres) of interstratified small boulders and coarse gravels, a second terrace lies against the foothills in which the fragments are larger (over 30 cm. in diameter), and not only such as would come from the neighbouring coarse granite region, but more often syenite and types of felsite such as occur in the Ferani range. These gravels which abut against the granite are of the usual pebble-gravel type referred to in A. In contrast to the above, there occur in the lower part of Wadi Nasb, and especially close to its junction with Wadi Abuksheib, certain terraces resting on Nubian sandstone and granite, containing boulders of syenite, biotite-gneiss, felsite, and red granite (often over one metre in diameter) *cemented together by crystalline calcite* in the form of well-developed scalenohedral crystals. This curious occurrence has only been noted in this neighbourhood, and higher up the valley a little west of the point at which Wadi Ra'ib joins Nasb, so that at present it remains a peculiarly local development.

E.—Travertine and conglomerate cemented by Travertine.

The question as to the origin of the cementing calcite in this and the previous case admits of at least three possible solutions, two of which would regard the chemical changes as still proceeding, while the third refers the action to effects which are no longer in operation. The second view depends upon the fact that the felspathic constituents of diabases are known to readily undergo decomposition resulting in the formation of calcite, and these being everywhere abundant as dykes in the granite, etc., might easily give rise to soluble bicarbonate which subsequently is re-deposited as travertine. In support of this hypothesis might be mentioned the apparently close connection of the calcareous deposits and the present valleys, though it would require an analysis of the torrent waters to show whether carbonate of lime is in sufficient quantity to have the above-mentioned result. The third hypothesis assumes that the depression above-mentioned affected the Sinai Peninsula to the same extent, in which case nearly the whole of the southern valleys would be submerged, as well as the lower part of Wadi Nasb and its tributaries, and calcareous deposits might then be laid down, but the comparative rarity of these beds renders it inadvisable to bring in an assumption involving wide-spread physical changes, where a simpler explanation is available.

Summary.

It will thus be seen that the gravels everywhere bear evidence of movements of elevation, erosion now in all cases exceeding deposition, while if the oolitic calcareous sandstones are of marine origin they involve a differential movement of at least 700 metres in Pleistocene times. It has further been shown that these gravels must themselves be of late origin, as they overlie coral reefs containing Pleistocene shells.

CHAPTER VIII.

CORAL-REEFS.

At the commencement of a paper * above-mentioned, occurs the following statement :—"The shore-boundary rich in corals is entirely wanting in the Gulf of Akaba. Only to the east of Ras Mohammed small fringing reefs (Schirmriffe) are found against the steep slopes of the cliffs and more extended reefs of younger Tertiary age are

* Walther, *loc. cit.*, p. 40.

also to be observed. In the main gulf there are also small coral aggregations at the mouth of Wadi Nasb and Wadi Ghazaleh. Immediately beyond the shore depths of 60 to 150 fathoms have been noted, while at the exit of the Tiran Straits, bottom was only touched at 594 fathoms. Therefore the Gulf of Akaba presents itself as a deep rift, bounded by steep slopes, and poor in reefs." The same impression for the southern end is left by a study of Moresby's Admiralty chart, which was probably followed by Prof. Walther, as the latter does not himself appear to have visited the shores of Akaba. As a result of the present expedition, the views expressed above must be finally abandoned, Skill having now mapped practically continuous reef from Dahab to Ras Mohammed, wherever it was possible to observe its outlines from the shore. It forms an almost continuous fringe which renders approach to the coast dangerous for even small boats, except at a few localities, such as Dahab, Nebk, and Sherm.

The Fringing reef and Lower Coral series.

The fringing reef is in reality one of the most conspicuous features of the gulf, extending from the shore as a white, narrow, usually submarine ledge, its outer border being marked by a long line of surf, beyond which the water is of intense dark-blue colour, due to its great depths. Closely associated with it, but at a higher level, is a second reef, which to the north forms isolated terraces up to 25 metres high, standing only a little way back from the water's edge. The former is naturally the one which attracts the attention of the zoologist, but the latter is also characterised by a very rich and varied fauna.

Lower Coral series.

The Gulf of Akaba was first visited at the northern end of the narrow plain which bounds the southern hills of the peninsula to the east, a cliff 15 metres high rising somewhat abruptly out of the gravel plateau at Ras Atantur. The hard beds at the top of this ridge are of coral limestone, the Astræan corals composing it being very abundant and large, (*Orbicella Forskaliana*, E. and H.), while associated with them are round pieces of granite, schists, and other igneous fragments. Above the main reef is a thick bed of large pebbles, mainly igneous, while below it are soft, salt-bearing marls, in one place containing a band of broken oysters (see Miocene). At the foot of the main cliff is a raised beach, composed of large shells, among which *Tridacna* is

especially abundant, associated with *Conus*, *Natica*, and many other genera. Just above sea-level is a more modern beach containing much coral, sea-urchins, the red organ-pipe coral *Tubipora*, while red masses of *Polytrema* coat the larger shells. Further south the summit of the main ridge consisted of raised beach containing casts of an *Oliva* and bivalves, while in the Astræan coral limestone *Laganum depressum* is present. In the closely consolidated limestone below, many large spines and fragments of sea-urchins, the former of the compressed Echinometrid type (*Heterocentrotus*), are associated with large *Tridacna* and casts of Gasteropods, the whole being covered by a coarse pebble gravel, and being of Pleistocene age.

The sea-shore was again visited at Nebk, where the coral-reef forms a flat limestone fringe almost on the same level as the shore itself and completely covered at high water, no outstanding ridges being noted between Nebk and Ras Atantur.

A short distance to the south rise low terraces at first separated from the sea by a beach and small marshes, while close to the shore there is also a hard compact sandy limestone, in which bivalves and large Gastropoda are imbedded. The low cliff formed by these terraces contains *Heterocentrotus* spines, *Tridacna*, *Venus reticulata*, L., *Cardium leucostoma*, Bom., *Spondylus aculeatus*. Chem., *Cerithium Ruppelli*, Phil., *Pirenella mammilata*, (Risso), *Conus catus*, var., *nigropunctatus*, G. B. Sow., and *Conus textilis* L. var. *vicarius*, Lam., and *Ostrea*, and is capped by the well-marked Pleistocene Astræan corals, these beds being evidently identical with the *Laganum*-bearing strata of Ras Atantur. A traverse to the hills prevented a continuous study of the coral-reefs, but they were again met with north of Aad Bay. Here a calcareous sandstone nearly 2 metres thick and generally dipping 2·5° N. E., forms the base of the series, a very hackly stratum constituting the summit of the terrace consisting essentially of Astræan corals, innumerable casts of Gastropoda, and bivalves mingled with detrital material, especially quartz fragments. Near the sea the reef consists of massive limestones containing grains of quartz and felspar, blocks of coral, casts of shells, and perfect examples of *Cypræa*; while higher up are small blocks of granite and basic rock, about 2 metres in diameter. About 6 metres above sea-level *Tridacna*, sea-urchin spines, *Cypræa*, and the Astræan corals of single type bound together are abundant and good *Lithodomus* borings are noticeable. These, closely associated with numerous Nullipores, form a second shelf. The terraces increase in importance and height as Aad Bay is approached, corals abounding in the small bay, and being very varied in character. Turning slightly

inland, the nature of the strata is seen to undergo a change, the lower ones being full of large oysters, *Pecten*, *Laganum depressum*, a young *Clypeaster* and *Echinus verruculatus*, associated with these being deep-brown and greenish beds containing salt similar to those noted at the base of the coral reef in Atantur. In places these are capped with a pebble bed of granite, diorite, etc.

The best sections are those seen immediately north of Sherm, and from these the following typical succession may be given, beginning from above :—

1. Cavernous calcareous limestone (Older Coral Reef) which has undergone dolomitic alteration, containing *Orbicella Forskaliana*, *Goniastræa favus*, Forsk., and three other Astræan types, *Cœloria arabica*, *Anadara*, large gasteropod casts, Nullipores. Thickness one metre.

2. Coral and Millepore limestone, in places forming a small vertical cliff, and to the east changing into a compact white chalk, in which are casts of the large bivalve *Venus reticulata*. Four metres.

3. Oyster and Pecten beds, full of oysters, *Pecten Vasselli*, *Laganum depressum*, and the small *Echinus verruculatus*. These beds undoubtedly correspond to the *Pecten Vasselli* beds from kil. 152 of the Suez Canal, which yielded Fourtau *Echinus verruculatus*, *Tetrodiscus auritus*, *Temnopleurus toreumaticus* and *Laganum depressum*, var. *sinaiticum*. *

4. Brown and greenish salty marls, possibly Miocene.

These are *apparently* succeeded by

5. Nullipore rock.

6. Limestone with large ornate *Venus*, *Cypræa*, *Tridacna* and a large *Trochus*.

7. Limestone rich in Gasteropoda, etc., including the striped *Strombus*, *Conus*, *Dentalium*, sea-urchin spines (*Heterocentrotus*), *Goniastræa*, and several species of *Fungia*.

8. This limestone is separated from the sea-shore by two beaches, the higher consisting of larger spineless specimens of *Echinometra lucunter* associated with *Haliotis*, while the lower consists of small varieties of the same sea-urchin still covered with their spines.

Nos. 1 to 4 include the Older Coral Reef series, the latter being the oldest member and No. 1 the youngest.

Nos. 5 to 7 form a second terrace, and compose the Younger Coral Reef series, No. 7 being younger than No. 1, but older than 6 and 7. Finally, No. 8 is quite recent.

* See Fourtau, "Sur la faune échinitique du golfe de Suez." Comptes rendus, May 4, 1903.

PLATE XVI.

CORAL REEF, ETC., AT SHERM BAY.

These double terraces are broken across by the broad bay of Wadi Aad, whose shore consists of raised beach crowded with shells of the volutiform *Strombus*, large *Pteroceras*, *Terebellum*, *Cerithium*, and many bivalves including *Arca*, *Cucullæa*, etc. On the other side of the valley, the double terraces having again been crossed, a small hill in the plain some distance from the sea was ascended, and was found to consist of a semi-crystalline hackly limestone in which the only fossils present were a few traces of corals (in which the calyces are separated by cœnenchyma) and a *Pecten*. Its height is 52 metres above the second terrace and its beds are dipping 4° S. E. This was the first case met with in Sinai of tilted coral reefs such as will be described later, the fauna in which is usually so badly preserved as to render the determination of their geological position difficult.

Returning to the sea-coast the terraces are again crossed, these uniting toward Sherm to form a perfectly flat plateau composed of the *Cœloria* beds of the Upper Coral Reef, and having sandy granitic beds mixed with ochreous sands below, while at the base are ferruginous strata containing much salt. This reef contains large oysters, *Spondylus*, the ornamented *Venus* and *Orbicella*, associated with Barnacles, Millepores, and many badly-preserved corals. It can here be seen that the reef is unconformable to, and independent of, the underlying sand-rock, the latter dipping 4°. While in Sherm Bay the manganiferous gravels form the main portion of the cliff, the southern bay of Merza El Awaja is bordered by raised beach with shells similar to those of Aad, but as the rocky coast at the foot of Gebel Zafara is approached, the shells become of large size, the shore being strewn with *Tridacna*, *Fasciolaria* and *Pteroceras*. In Gebel Zafara the relations of the various beds are by no means easy to determine. This hill consists of sand-rock mainly derived from granite and strata of sandy limestone in which no fossils have been observed, while the rounded quartz-pebbles in them recall those of the Nubian sandstone. They dip 21° south-west, and at the southern base of the hill the coarse granitic sand-rock is overlaid by a very hackly limestone, from its cavernous structure being evidently an old coral reef. Immediately to the south commences typical "Upper Coral Reef," underlying which is gypseous sandrock and marl, the latter in places containing the large Miocene oysters subsequently described. Above these gypseous beds rounded pebbles and boulders of red granite and limestone make their appearance where coral-reef is absent, and become very coarse on the summits of some of the ridges. In the reefs themselves are casts of a dwarfed volutiform *Strombus*.

These low terraces extended between Zafara and Hedemia Bay, the shore of the latter being again crowded with a rich variety of tropical shells. South of the bay they are rich in shells including Astræan corals associated with small *Fungia* (including *F. dentigera, F. scruposa,* and *F. placunaria,* Gregory), *Conus* and *Cypræa.* The upper part of the series is composed of *Coeloria* limestone. Inland rise several yellow hills (Gebel Asfar), which on examination are seen to be formed of a very cavernous limestone. As noted from the summit of one of these, the distribution of the sedimentary hills with regard to the granite and the variable direction of the dip suggests that these limestones have been faulted down by north-south and east-west faults, the "Upper Coral Limestone" having been subsequently laid horizontally on their flank. The dip of the cavernous limestone where first observed was 15° south-west, then swinging round to 30° east (see map). On leaving this point, a second coral hill to the south was visited, the beds in which were tilted at an angle of 60°, being very crystalline, but still containing recognizable oysters and casts of *Pecten.* The crushed appearance of the beds close to the felsite region, and the presence of quartz-rock, points to the existence of a strong fault at this locality.

Returning to Hedemia Bay and following the coastline, our road lay among the coral reef series, which forms a thin covering to sandy beds with red ferruginous bands and lines of pebbles dipping 4° south-east, while in the small valleys a flaggy rock of granitic material also appears at the base, having the same dip.

The district between Hedemia and Ras Mohammed Bays is entirely occupied by the two coral terraces; the Lower Coral Limestone is crowded with shells, some species being locally more developed than others. Thus at one spot the rock contains flattened sea-urchin spines and the striped *Strombus* in abundance - elsewhere the latter is associated with *Conus*, these being perfect below, but only in the form of casts near the summit of the lower terrace. The highest point of the latter is almost entirely occupied by a *Pectunculus* bed, above it being over 10 metres of an unfossiliferous hackly limestone, probably part of the Upper Coral Reef.

The lower reef north of Ras Mohammed Bay is characterised by the large size of the Gasteropoda present, especially *Terebra* and *Murex*; while *Tridacna*, the striped *Pectunculus*, *Dentalium*, and many other molluscs, are associated with them. At the head of the bay is a hill consisting of very wind-swept crystalline limestone, furrowed into long ridges, the impact of the pebbly particles having apparently produced crystallisation. In it casts of *Turbo*, *Conus*, *Cypræa* and

other bivalves were still recognizable, associated with small *Fungia* and a single-pored coral which has undergone much alteration, internal casts of its calyx being alone present.

The fringing reef was traced all round the outside margin of the land, near Wadi Ghazlani being two metres below the surface; on the northern side of Ras Mohammed it is almost on shore level, and though apparently a flat limestone surface, is in reality filled with small pools and depressions, in which living Ophiurids find a congenial home, sometimes associated with beautiful crimson *Stylasters*. There are also near the shore a number of small outgrowths from the main coral floor, which curiously simulate atoll structure. Near the cape itself the coast rises, and from the summit of the cliff, the reef is seen to form a narrow fringe over which the surf is constantly breaking, while several large blue-coloured fishes were disporting themselves in the foam. Here the reef resembles an open network structure and seems to be merely a thin limestone film attached to the sides of the main rock and overhanging the abyss of deep water.

The raised beaches and Lower Coral limestone are well developed on the further flanks of the low hilly backbone which runs down the centre of the Ras Mohammed peninsula, on its northern side being a beach, chiefly composed of small *Cerithia* accompanied by minute *Nerita* and bivalves. Nearer the sea the coast becomes sandy, and further to the south-east the Lower Coral limestone forms a low ledge. In the small rocky bays is a modern shell-beach composed of the larger shells, such as *Tridacna* and *Pteroceras*. On the southern side extends a plain which is cut off from an island by a long arm of the sea; this is entirely composed of the striped *Strombus* beds, also crowded with *Pectunculus* and *Oliva*, while on the eastern side of the axis *Oliva*, *Murex ternispina* and other large forms characterise a higher beach, these being replaced towards the sea by the small *Cerithium*, which is present on the flat shore in great abundance. The central axis of Ras Mohammed is composed of a limestone ridge, which at its extreme point rises to 90 metres above the sea, and whose strata dip at an average angle of 4° south-west. These are formed of hard limestones and cast-beds, containing casts of corals, *Conus* (?), *Spondylus* (?), strata of oolitic nature also being present. Further south is a Nullipore limestone also containing gasteropod casts, and only in a lower ridge does the true Upper Coral Limestone make its appearance. As Walther has remarked, the preservation of the fossils is such in the oldest reef as to render the determination of the age of the latter very difficult. The prevalence of the north-east wind is well marked by the

deep grooves running parallel to that direction in the coral limestone, which is also remarkably broken up by fissures running mainly in an east-and-west direction.

Having thus dealt with such details as are necessary, special stress may be laid on the following general points :—

The coral reefs of the Gulf of Akaba show the following distribution : south of Aad Bay and Sherm there are conspicuous tilted coral hills, and two horizontal terraces representing Pleistocene reefs of different ages. Going north, between Nebk and Aad Bay, the two latter are alone represented, the tilted beds being absent. Finally, north of Nebk, only the Lower Terrace or Younger Coral reef and the recent fringing reefs are observed, there being no trace of raised coral beds high on the sides of the hills such as have been noted on the Red Sea coast. In other words, *the Older Reefs are only present at the southern end of the Gulf of Akaba.*

Coral Reefs formed in a region of elevation. From what has been said above, it is obvious that only one conclusion can be arrived at, viz., *that the coral reefs of the whole of this region have been formed during a movement of elevation, the oldest one being at the same time the highest, while the upper terrace is composed of beds which are older than those forming the lower terrace.* This elevation is directly proved from the present height of the coral reef to be at least 200 metres in amount, and the question arises, is it still being continued ? For the Gulf of Akaba, the answer is perhaps a slight negative, the chief grounds for this conclusion being the discovery made by Walther, that a reef, probably dead from its striking white colour, exists under the present submarine living one, suggesting a local depression of about 6 metres, and the same idea occurred to me as an explanation of the fact that so many inlets from the gulf are only intrusions of the sea up the mouth of the valleys.

Thus Ghaslani, Sherm, Aad, and Nasb bays are all of this nature. The only other alternative would be that the material brought down by rains from the hills had had an unfavourable effect on the growth of the reefs, but against this theory many objections can be urged. *It therefore appears probable that a small local depression* (at present amounting to 6 metres according to Walther) *is taking place in the Gulf of Akaba*, the latter differing in this respect from surrounding regions.

It will now be of general interest to take up the five questions which Walther set himself, and see how far the Gulf of Akaba leads us to agree with or differ from his conclusions.

1. To what thickness may coral reefs attain ? In this respect our

agreement with Professor Walther is absolute, viz., that *a coral reef does not attain any great thickness.* Thus to the north of Sherm a bed mainly composed of corals just exceeds 1 metre in thickness, and if the underlying limestones, *Pecten* beds, etc., be taken into account, 6 metres is the maximum noted. Presumably Walther has included these beds also when he gives the thickness of the younger reef at Ras Mohammed as 9 metres, and the older at about 7 metres, while the recent reef does not exceed 3 metres. The greatest thickness of raised limestone observed on the gulf is 54 metres, yet an examination of the component rocks will show that in all these beds true coral reefs are of comparatively rare occurrence, strata composed of millepores, calcareous algae, and broken fragments of sea-urchins, mixed with innumerable gasteropoda, being more conspicuous elements.

2. What is the basis of a coral reef? On this point our results differ to a certain extent, and especially in one particular to be referred to later. The upraised reefs give good opportunities in many cases for a close study of the base on which rests the limestone of the coral series, and it is seen that the latter varies very widely at different localities. Thus at Dahab it consists of granite gravels which near the junction are full of large boulders of the igneous rocks, while at Atantur only soft, salty marls are visible beneath the coral limestone. From Dahab to Atantur no base rock has been observed, but the reef projects directly from the hills composed of gneisses and hornblende-granite, immediately outside which the sea sinks to great depths, so that it is probable that the coral has grown directly on the detrital materials derived from the neighbouring mountains. Immediately north of Sherm, a junction is again beautifully displayed, the coral reef resting unconformably and horizontally on the underlying sand-rock (probably Nubian sandstone) which here dips at four degrees, while elsewhere it overlies gypseous sandrock and marl. Again, near Hedemia Bay, our field notes read: "The road taken lay among the coral-reef series which forms a thin covering to sandy beds with red ferruginous bands and lines of pebbles dipping four degrees south-east, while in the small valleys a flaggy rock of granitic materials also appears at the base, having the same dip." Walther, after a careful discussion of the relations of the base to the coral reef (*loc. cit.* pp. 496, 498), answers the above questions as follows: "The fossil, and probably also the living coral reefs of the Sinai Peninsula are based on the outcrops (Schichten-kopfen) of compact *sedimentary* (the italics are ours) rock, they are wanting on the softer and more crumbly coast-

rocks of the Sinai peninsula." The discussion and conclusion both suggest that the igneous rocks are of little use as bases for reef formation. but if this be the right interpretation of Walther's view, strong exception must be taken here to such a limitation, which would render it impossible to account for the existence of the fringing reef bordering the hills south of Dahab. Indeed elsewhere, on the western side of the Red Sea and on the eastern border of Gebel Esh, where coral-reef is tilted over 20° all along the sides of the igneous hills, the limestone is only separated from the underlying granite by a thin granitic conglomerate, and near Qosseir there is scarcely any detrital material between the diabases and the coral bed plastered against them. Instead, therefore, of having any limitation, we conclude that in general, *the deposition of a coral reef is practically independent of the nature of the rock forming its base.* Our own experience now includes red granite, diabase, sandrock, and marls amongst the basal members, with gneiss and hornblende-granite as highly probable.

3. What rôle does detrital filling material play in the living reefs? Practically there is nothing to add to Walther's statements. He very justly points out the easily breakable character of the madrepores and the importance of the calcareous algae, such as *Lithothamnium* and *Lithophyllum*, in binding together the broken fragments or forming a crust over a sandy floor, on which basis a coral reef can be built up. It may here merely be further stated that attention is also called by the above writer to the importance of crabs in breaking up the organic remains, producing the fine calcareous sand which fills the cavities between the dying coral-stems, and in addition may be noted the abundance of the red encrusting foraminifer *Polytrema*, the fragments on the shores of the gulf being in places completely overgrown by this bright-coloured organism.

4. What alterations do the reef-sediments undergo when they finally rise out of the water?

The effects of change are only too quickly visible, the brilliant-coloured living reef being replaced nearer the shore by the dead-white surface so familiar to all students of coral deposits. As the coral limestones are examined the observer cannot fail to be struck with the absence of many forms, which on the sea-shore itself seem to be the principal members of the fauna. In vain will traces of crabs be sought for, though on the beach they occur by thousands, while the beautiful *Phyllacanthus*, the large *Heterocentrotus*, and many other fine sea-urchins, are only represented by spines in varying degrees of

preservation. Though Ophiurids fill every pool, they leave no record behind them, and if it were not for the abundance of Mollusca and the corals, but little would be left to recall the life and movement of the tropical marine fauna.

No doubt this disappearance has in large measure to do with the *instability* of the *aragonite* composing the skeletons of many of the above-mentioned animals, while in addition, in the higher parts of the reef, the progressive formation of casts from shells of *Strombus*, etc., can be watched in all its various stages. But this is not the only change to which a coral reef is subject, and the upper terrace has lost its whiteness and taken on a dusty grey appearance, which is indicative of the further chemical alteration, viz., *the passage from limestone to dolomite by the increase in magnesia.*

This change is too well known to require further pressing here, and Walther's analyses show how far it has advanced in some of the reefs. As a result the coral structure has become practically obliterated, and in the older reefs, where the correct identification of the fossil contents is of first importance, the collector finds only unidentifiable casts, or at most the last traces of calices and septa.

5. The final question—What alteration in form and extension of reefs has taken place in the course of geological history?—has been answered as far as possible previously, but it may be here repeated, that apart from the tilted limestones whose age still remains uncertain, the two horizontal raised reefs do not appear to be older than the Pleistocene, north of Nebk the Pleistocene terraces, but little above sea-level, being alone present.

CHAPTER IX.

MIOCENE ROCKS.

(Originally published in Geol. Mag. June, 1904, pp. 250-252.)

The study of Egyptian geology during the last few years has thrown a flood of light on the former extension of the Mediterranean southward in Miocene times. Th. Fuchs,* in examining the rich collections from the Cairo-Suez desert and the oasis of Siwa, recognized that the

* Th. Fuchs, "Beiträge zur Kenntnis der Miocenfauna, etc.," in Zittel, "Erforschung der Libyschen Wüste," p. 36.

Miocene strata had a close resemblance to those of the Vienna Basin, and corresponded to the Grunder beds at the base of the second Mediterranean stage, or the lower portion of the Middle Miocene. Later L.H. Mitchell *, when studying the neighbourhood of Ras Jemsa and Gebel Zeit in 1887, obtained a number of large oysters, which Meyer-Eymar recognized as *Ostrea crassissima* and *Ostrea gigantea*, and which were regarded as proving the existence of strata of Upper Miocene age along the western border of the Suez Gulf. From these results Blanckenhorn † concluded that the Gulf of Suez must have been a Mediterranean bay in Miocene times, and further noted (Zeitsch. Deutsch. Geol. Gesell., Band liii, 1901, p. 79) that characteristic Miocene Pectens, viz. *Pecten Sub-Malvinæ*, occurred in the collection made by Barron at Abu Sha'ar. He further formed the opinion that all the marine Miocene strata in Egypt were of the age assigned to them by Fuchs (see also Barron and Hume, "Miocene Rocks in Eastern Desert," Memoir of Egypt. Geol. Surv., 1902, pp. 159-165).

Strata of similar age were first found in the Sinai Peninsula by Bauerman in 1868 ("Note on a Geological Reconnaissance in Arabia Petræa," Quart. Journ. Geol. Soc., xxv, pp. 24 and 37), and were subsequently examined by Rothpletz ("Stratigraphisches von der Sinai-Halbinsel," N. Jahrb. für Min., 1893, i, p. 103) and Blanckenhorn (Zeitsch. Deutsch. Geol. Gesell., Bd. liii, 1, 1901, p. 75), the latter tracing them from Wadi Gharandel to the mouth of Wadi Tayiba. When examining the southern end of Eastern Sinai, the present writer was surprised to find beds of large oysters in the terraces a few kilometres south of Sherm, at the foot of a marked transverse range, the Gebel Zafara, these being especially marked in Wadi Khoraiya. On comparing these with the oysters from the Miocene west of the Suez Gulf, there seemed little doubt that the species were identical, but to fully establish the point the specimens were submitted to Dr. Blanckenhorn, who has recognized the oysters of Wadi Khoraiya as *Ostrea Virleti*, Desh., and typical *Ostrea gingensis*, var. *setensis*, Blanck., while *Ostrea Virleti* was further recorded from a limestone above brown sands between Nebk and Sherm. The latter was evidently derived from the older Miocene series, but is now associated with Pleistocene fossils.

In a paper on the geology of Eastern Sinai (International Geol.

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* L. H. MITCHELL : "Ras Gemsah and Gebel Zeit : Report on their Geology and Petroleum" ; Cairo, 1887.

† M. BLANCKENHORN, "Die Structurlinien Syriens und des Rothen Meeres" : Richthofen Festschrift, Berlin, 1893.

Congress, Paris, 1901) the writer called special attention to the existence of certain highly-tilted beds occurring at the southern end of the peninsula, in most cases standing well back from the sea and having undergone extreme alteration. South of Gebel Zafara these are well developed, forming a series of yellow hills close to the junction of the igneous rocks, and rising nearly 200 metres above the sea. Here the beds have been tilted to an extraordinary extent, in some cases dipping from 30° to 60° E., and being apparently connected with a longitudinal fault of importance. In the paper above-mentioned it was further pointed out that their appearance recalled the altered coral reefs of this region, and that they still contained oysters and casts of *Pecten*, but their age was not then definitely stated. The identification of the oysters of Khoraiya leaves little doubt, however, that these beds also are of Miocene age, and we therefore arrive at the conclusion that the *Older Tilted Reefs at the southern end of the Gulf of Akaba are Miocene in age* and agree with those on the western side of the Gulf of Suez. Dr. Blanckenhorn has made some observations in sending the specimens which it may be of interest to quote here. "It is to be assumed that *Lithodomus* (*Botula*) *cinnamomea*, *Gastrochæna Retzi*, oysters of the *crassissima-gingensis* group, *Lucina* sp. aff. *tigrina*, and corals like *Cyphastræa chalcidicum*, etc., persisted from Miocene to Pleistocene times in the Erythræan region in a salt 'Binnensee' situated somewhere in the deepest part of the Gulf of Suez. In the Upper Pliocene there was the second invasion of Mediterranean forms into the Erythræan region. At this point there came in *Pecten varius*, *Pecten benedictus*, *Cerithium conicum*, *Ostrea cucullata* and *O. plicatula*, *Arca lactea*, etc. Possibly in the neighbourhood of Sinai there may be a place which still contains remains of this more continental transition period between the Middle Miocene (Helvetian) and the Upper Pliocene. Might the N°. 4798 [this is the above-mentioned *Ostrea gingensis*, var. *setensis*, of Wadi Khoraiya] be included here?"

Having seen the deposits from both the Eastern Desert of Egypt and Eastern Sinai, it seems to me impossible to separate the two, and if the former are Helvetian the latter must also be of the same age, so that the conclusion is forced on us that the Gulf of Akaba (at least in part) was already occupied by the sea at this early period. The question thus opened is a wide one, and whatever its solution demands far-reaching hyphotheses. Did the Miocene sea extend over the whole peninsula, and are these but faulted relics of this Mediterranean advance, or was the present configuration of this district so far outlined that two arms of the sea already bounded the Sinai Peninsula, though connected

with the Mediterranean instead of the Red Sea, as at the present day? In the central Sinai ranges no traces of such strata have been met with in the fault-valleys, and the final answer will probably only be obtained when the plateau of El Tih has been more closely examined. The other alternative appears to be that fault or rift action had begun at a far earlier date than is usually assumed.

In any case it can now be definitely stated that *Miocene* strata of well-marked character are also present in the Gulf of Akaba area, and Barron * has found *Pecten*, *Ostrea*, and *Heterostegina* beds of the same age to be present in the whole sedimentary area of the west of Sinai.

CHAPTER X.

CRETACEOUS LIMESTONES AND NUBIAN SANDSTONE.

As previously stated, the older sedimentary strata only appear in the northern part of the area studied by the Survey (see Plate XXII) where in the neighbourhood of Ain el Hudera, they form an important element in the structure of the country. Viewed in broad outline, the Cretaceous limestones have given rise to the rolling upland plateau of Gebel Gunna, which terminates in a steep escarpment facing southward; but between it and the igneous ranges is the Nubian sandstone region, where isolated masses of white sandrock, now cut by vertical furrows to their very base, rise as isolated buttresses over 100 metres high, bounded on all sides by vertical walls. Between these extend broad, smooth-surfaced plains, in general sloping gently northward, due to a hard ferruginous bed overlying variously-coloured ferruginous sandstones, which themselves have been deposited on a planed-down surface of granite. These relations have been complicated by the faulting to which the region has been subject. Owing to the existence of the Ra'ib rift, these strata are separated from the sea by the long range of granite which extends from Noweiba to Dahab, and similarly granite hills rise from among them, or tongue into them, in a bewildering manner when first observed, though a closer study renders it possible to trace the various faults and folds which have caused the complexity. To the same cause are due the outliers of Um Raiyig,

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* The details will appear in the Survey Report on the western side of Sinai Peninsula.

Wadi Ra'ib, etc., remnants of the Cretaceous plateau which have been preserved in the fissures, while the same beds on the mountain summits above have long since disappeared.

1.—Cretaceous Limestones.

The detailed section of these strata is obtainable with great accuracy on the slopes of Gebel Gunna, and the following thicknesses were determined by aneroid measurements. The succession is as follows, beginning from the summit.

	Thickness in metres.
(1) Summit of escarpment composed of ferruginous limestone of hackly character, having a well-marked oyster-bed, from which the fossils could not be obtained in recognizable form owing to the compact nature of the rock *	61.0
(2) Limestones, whose upper beds contain *Echinobrissus* and *Diplopodia variolaris*, whilst in the lower one bivalve casts are abundant	22.5
(3) Limestone with *Exogyra olisiponensis* followed by a characteristic striped series of green marls containing a typical Cenomanian fauna, viz., *Periaster oblongus* (first noted by Duncan),† *Tylostoma elatius* and *Heterodiadema libycum*.....	3.5
(4) Loose sandstone and marls, containing large *Exogyra olisiponensis* in abundance	14.0
(5) Forming base of hill white grits of the Nubian sandstone, the uppermost 10 metres being more compact, owing to the presence of lime ‡	200.0
	301.0

Um Raiyig.—The outlier of Gebel Um Raiyig also gives an excellent section of the fossiliferous beds, the succession being as follows:—

Summit.

(1) Bedded limestones, from which no fossils were obtained.

(2) Strata containing numerous *Tylostoma* and *Cucullæa*, a cast of a *Nautilus* having also been obtained. Thickness 18 mètres.

(3) Compact limestone with large casts of *Tylostoma globosum*, in the downwash being numerous specimens of *Periaster oblongus*.† Thickness, 6 metres.

* These strata have been much disturbed, and have a minimum dip of about 30 degrees, this being due to faults, which are prominently developed on the sides of Gebel Ghlim to the east.

† Probably the one usually classed by later writers on Sinai as *Hemiaster cubicus*. The echinoderm fauna obtained by the Survey in Sinai having been submitted to Prof. J. W. Gregory for examination, he has recognized the following new species in the collection from the Cenomanian of Jebel Gunna: *Heterodiadema bigranulatum*, n. sp., *Acanthechinopsis Humei*, n. sp., *Micropedina bipatellis*, n. sp., *Coptosoma gunnehensis*, n. sp. In the Um Raiyig collection he notes *Holectypus cenomanensis*, Guer., *Micropedina bipatellis*, n. sp., *Nucleolites daglensis*, (Gauth.) and *N. gibbosa* (P. and G.). See *Gregory*, *Geol. Mag.*, No. 503. Dec. V., vol. III, n° 5, pp. 216-227.

‡ With the exception of the faulted strata in N°. 1, the dip throughout the series was practically nil.

(4) Green, closely-banded marls consisting almost entirely of *Ostrea Rouvillei*.

(5) White sandrock of the Nubian series.

These Cretaceous beds as a whole form a syncline, dipping north at the southern end, while to the north the dip is reversed.

Gebel Ejjibi. In Gebel Ejjibi the succession is very similar, the *Ostrea Rouvillei*, *Tylostoma* and *Periaster* beds being all represented. These strata appear to be repetitional, and the strike of the beds is a marked curve, with a westward dip predominating. Blocks derived from a bed almost entirely composed of *Ostrea Rouvillei* were abundant on the slopes of the hill, associated with large Exogyrae (*E. olisiponensis*) and many fragments of ferruginous sandstone.

The thicknesses of the strata are as follows :—

Summit.

1. Compact limestones.............................	over	33	metres
2. Oolitic and compact limestones...................	„	7	„
3. Compact limestone and marls....................	„	23	„
4. *Tylostoma*, *Periaster* and *Cucculaea* beds...........	„	12	„
5. Red, more sandy bed	„	1	„
6. *Tylostoma* and *Periaster* bed......................	„	6	„
7. Beds of more marly and gypseous nature with 1 metre band of casts of *Exogyrae*......................	„	5	„
8. Brown-red sandy bed	„	1	„
9. White friable sandstone.........................			

In bed No. 1., at 11 metres above its base, is a bed of small shells and sea-urchin spines, while nearer the summit traces of mollusca are numerous, but not sufficiently well preserved for identification.

A fourth occurrence in a hill north of Gebel Um Raiyig is very similar in its character, the faulting having brought the fossiliferous Cretaceous strata into direct contact with the massive bedded white Nubian sands. At the base of this hill are the brown *Tylostoma* limestones, above these being an *Exogyra* bed with many sea-urchins, which is succeeded in its turn by an *Ostrea Rouvillei* layer.

Separated from the preceding by a bivalve-cast limestone is a soft green marl weathering red, and full of small *Echinobrissus* and *Strombus*, (E. cf. *angustior*, Gauth., determined by M. Fourtau*), accompanied

* His remarks on these specimens are as follows :

Echinobrissus near *angustior*, Gauthier, from the Upper Cenomanian of Bou Saada. This species is also present in the Upper Cenomanian of Tunis. It would be more prudent to regard this as a local variety *sinaica* than as a new species.

The presence of the *Cyphosoma* is also significant as no true Cenomanian *Cyphosoma* has as yet been recorded from Algeria and Tunis.

by a few specimens of an ornamental regular echinid. (*Cyphosoma* aff. *majus*. Coq.) The whole series is crowned by flaggy and brown compact limestones, the latter containing casts of vertebræ. (In the field-notes possible signs of worm-tracks and rain-prints were also mentioned).

Mr. Bullen-Newton has recently identified a number of the Cretaceous forms above-mentioned, and from Um Raiyig records *Strombus*, allied to *Arnaudi*, Péron; *Tylostoma globosum*, Sharpe; *Exogyra olisiponensis*, Sharpe; *Exogyra africana*, Lam.; *Gryphæa vesiculosa*, J. de C. Sow.; *Diplopodia variolaris*, Brong.; *Linthia oblonga*, d'Orb.; *Hemiaster scutiger*, Forbes; *Hemiaster Heberti*, Coq. and *Goniopygus Menardi*, Agassiz. From Gebel Gunna he has recognised *Nerinæa mamillæ*, Fraas, of which only one specimen was obtained by the writer; *Tylostoma elatius*, Coq; *Ostrea*, probably a new species, allied to *lignitarum*, Coq. and *Exogyra olisiponensis*. He further notes that these specimens appear to belong entirely to the upper or younger division of the Cenomanian stage, as some of the species pass up into Turonian rocks, especially in Portugal.* The Sinai beds are obviously closely related to those in Egypt which were originally classed by Professor Zittel under the name "Africano-Syrian" series, and which have now been shown by many writers to extend from Baharia through Gebel Gallala to Sinai itself.

The Eastern Sinai beds differ in some respects from the strata of the same age to the west, more especially in the absence of two characteristic Exogyræ, *E. flabellata* and *E. suborbiculata*, Lmk., which are still found in great abundance in Western Sinai, but appear to be markedly absent in the beds now under consideration.

M. Fourtau has recently † also dealt with the Cretaceous subdivisions and fauna. He holds that both in Egypt and Sinai the Cenomanian begins below with chloritic marls containing *Hemiaster cubicus*, Desor., and *Ostrea olisiponensis*, Sharpe, in abundance, the beds being of Uraconian age and corresponding to the Bellusian of M.Choffat. Then follow limestones and marly beds with *Ostrea africana*. The upper part is a siliceous limestone with *Heterodiadema libycum*, Cott., *Hemiaster pseudo-Fourneli*, P. et G., and *Ostrea suborbiculata*, Lmk. The resemblance to the series in Algeria is very striking. He considers that the term "Africano-Syrian" is too limited, the Cenomanian strata of similar character ranging more widely than the name indicates and therefore recommends the use of the term "faciès Mesogéen."

* (See Paul Choffat: Syst. Crétacique de Portugal, 1900).
† (Bull. Inst. Egyptien, April. 1903. Étude de la Fauna Crétacique d'Egypte. pp. 232-347).

It is evident that the higher fossiliferous beds of East Sinai are practically at the junction of the Turonian and Cenomanian series, the coming in of *Cyphosoma*, the abundance of sea-urchins of the *Periaster* type, and the character of the *Tylostoma* species all pointing in the same direction. Among the latter a very inflated species has been obtained, which in every respect resembles the *Globiconcha ponderosa* recorded by Coquand, and described by him * as occurring in the Carentonian (Upper Cenomanian) of Tenoukla.

If these beds are uppermost Cenomanian, the main limestone of the escarpment is of Turonian or even later date.

Nubian Sandstone.

The Nubian sandstone unfortunately is not as yet of palaeontological or economic interest, the well-known Carboniferous limestone of Wadi Nasb thinning out eastward before entering our region, and there is therefore no proof that any of the Ain el Hudera sandstone is Carboniferous. Indeed throughout the whole of the 200 metres of sands and sandstone, no organic remains of any kind were noted. The sandstone itself falls lithologically into two series (1) the white or variously-coloured sand-rock, and (2) ferruginous sandstones, the latter forming the base of the series. These relations were well seen when examining the various sections observed in the peninsula. The Nubian sandstone was first met with at the junction of Wadis Nasb and Shelala, where it has been let down in the Nasb-Shelala rift. It here consists at the base of variegated banded sandstone, very gritty in places, and containing well-marked purple, pink, and yellowish-white bands, one yellow ferruginous layer being especially conspicuous. The whole is dipping 12° north-east. Above these ferruginous beds is a thick mass of sand-rock, which near the base contains a number of small quartz-pebbles up to 12·5 mill. in diameter.

Owing to the compact nature of this rock, it overhangs the underlying strata in consequence of differential weathering. The unconformable junction of the whole series with the igneous rocks is well-marked, the sandstone having been laid on a planed-down granite surface penetrated by a diorite dyke. The great mass of sandstone which separates Wadis Shelala from Wadi Rahab is over 100 metres (358 ft.) thick, and dips 16° 5 east.

Owing to the absence of identifiable fossils, it is impossible to say with absolute certainty that Nubian sandstone occurs south of this

* (Geol. Province Constantine p. 178).

point, but judging by lithological characteristics, its existence in Southern Sinai is highly probable. This is notably the case under the marked terraces existing near the mouth of Wadi Kyd, a yellow sandrock being here present, which contains rounded pebbles similar to those of Wadi Shelala. North of Sherm, the coral reef rests unconformably and horizontally on the underlying sandrock, which there dips four degrees, while near Hedemia Bay, the coral-reef series overlies sandy beds with red ferruginous bands and lines of pebbles dipping four degrees south-east, and in the small valleys a flaggy rock composed of materials derived from granite also appears at the base, having the same dip. These rocks extend to the southern end of the peninsula, where a low hill is in large part composed of southward-dipping sands and hard ferruginous sandstone with yellow ochre, the whole being capped by hard crystalline limestone.

These sandy beds would have been unhesitatingly referred to the Nubian sandstone, were it not that strata of very similar character alternate with sandy limestones in the slopes of Gebel Zafara, and limestones are never associated with typical Nubian sandstone in Eastern Sinai. The probable explanation of the difficulty appears to be that the Nubian strata are developed in the south, but have been in part denuded and re-assorted to form new strata of Miocene age, the older sandstone having been preserved owing to faulting along the line of the Gulf of Akaba.

Wadi Ra'ib, etc.

As in Wadi Shelala, so also in Wadis Ra'ib and Dahab, the Nubian sandstone is found in the valley far south of its main outcrop. This is especially the case at the junction of Wadis Dahab (Nasb) and Abuksheib, where a thick mass of Nubian sandstone has been faulted down. Resting directly on a sloping platform of granite and diabase, it consists at the base of a grauwacké, followed above by purple sandrock and grits. Isolated blocks of the same nature are scattered up the valley, one of these in its centre being purple-coloured, and consisting of a very friable ferruginous sandrock, passing rapidly into a perfectly white grit. In both the weathering is tabular or cubical in character.

Nubian Sandstone on Granite Plateau.

The interest of this occurrence has already been emphasized in connection with rift-action, the Nubian sandstone being also present on the summit of the plateau which rises 300 to 500 metres above Wadi

Ra'ib, &c. Here it occurs as isolated knobs or outliers, being well-banded, with red and yellow-coloured stripes ; the layers are often beautifully curved, and the rock itself is extremely friable. The granite has been planed to a flat surface, where the sandstone rests upon it. The most prominent outlier is Gebel Rai'emshi, where the sandstone has been laid down on the granite. At the base the beds almost entirely consist of irregular quartz grains from 3 to 6 mill. diameter, whilst higher up the rock becomes more compact, finally passing into a white sandgrit. Further north, in the Berga plain, these fine-grained white grits contain beds of hard ferruginous sandstone, which give rise to the long flat slopes of Al Fara. There is probably a fault at the west end of this plain, the Nubian beds being lower than the granite ; their dip is on the average 2 to 3 degrees northward, but in places rises to 8 degrees, possibly due to slipping.

It would be wearisome to describe every section exposed in detail, it will suffice to note that along the main outcrop of these beds the series consists at the base of bright-red and purple sandstone, weathering to a uniform yellow-brown tint, and practically made up of sandgrains.

In places bands of yellow colour are intercalated, and in addition there is a complex tiger-skin structure, due to the alternation of purple and white sandstone stripes. Above these purple and red beds are outliers of white grit, forming bold masses with vertical walls, and often fretted with a rectangular pattern of a very regular kind.

Cannon-ball concretions are also often present in the white grits, these being more especially prominent near the summit of Gebel Amutamir.

Origin of the Nubian Sandstone.

The origin of this widely-spread sandstone formation has been hitherto wrapped in mystery, owing to the uniformity of its lithological conditions and absence of organic remains. Extending in Egyptian territory from its uttermost western confines in Dakhla Oasis to the extreme eastern boundary in Sinai, it cannot be dismissed as a mere local occurrence, and it is therefore not surprising to find so earnest a student as Walther stating that "a careful study of the so-called Nubian sandstone has led me to the conviction, that these sandstone beds are an æolian dune-formation and point to the existence of palæozoic and mesozoic deserts in North Africa." * This view has been also

* (Reprint from Verhandl. Ges. f. Erdkunde zu Berlin, 1888, N° 6, p. 10).

pressed by Fourtau.* In neither case, however, is the matter discussed in detail, and there are certain reasons which lead the present writer to a somewhat different conclusion as regards the origin of the sandstone itself.

In the first place it must be remembered that the sandstone is always laid down on a planed surface of the older rocks, whereas in the present desert region wherever igneous rocks are exposed they give rise to precipitous crags or rolling hills. One force only could have produced so uniform a level, and that is the invading waters of an advancing ocean. It would appear rather that the Nubian sandstone is the African equivalent of the terrigenous deposits, such as greensand, gault, etc., which in Europe mark the passage from continental to oceanic conditions. That the sandstone † is more probably of marine origin is also shown by the frequent presence of coarse conglomerates at its base, the extreme rounding of the quartz pebbles, and the rare presence of marine shells in it, as shown by Dr. Ball at Aswan, ‡ and the unbroken passage to marls containing marine faunas of definite age. The remains of fossil trees and leaves, and the existence of oolitic iron ore near Wady Halfa, on the other hand show that the continent was not far distant.

It may be freely admitted that the continent itself was probably under desert conditions. The brilliant colouring of the sands below and the fine-grained nature of those above certainly suggest the existence of vast dunes on the sea-border, and the absence of any traces of land-life all point in the same direction. It may therefore be concluded that the Nubian sandstone of East Sinai represents the shallow marine terrigenous deposits laid down during the depression of a continent, taking place during the various stages of the Upper Cretaceous, the formation extending, so far as known at present, from the Cenomanian to the Senonian.

CHAPTER XI.

IGNEOUS ROCKS OF EASTERN SINAI.

The complicated and intricate character of the Sinai peninsula is fully reflected in the igneous rocks composing it, these in a limited

* Comptes-Rendus, Nov. 10, 1902.

† As the Carboniferous sandstone, etc., is not at present known in East Sinai, the question of its origin is not included in the above discussion.

‡ The Upper Cretaceous species *Inoceramus Cripsii*, according to Dr. Blanckenhorn.

space illustrating many of the most difficult problems with which petrographers have to deal. The nature of their distribution and the precipitous forms of the hills in which the best exposures occur, render a study of the relations less easy than in the districts previously examined by the writer; on the other hand the general arrangement appears to be the same on both sides of the Red Sea.

On entering the mountain region at Wadi Isla, the rock forming both sides of the ravine proved to be essentially a *biotite-gneiss*, some of the foliation bands being darker and more micaceous than the main mass; it appears to agree in all its main characteristics with the low-country or gneissose granite previously described in the report on the Eastern Desert (p. 85 and 117), which is also developed on a large scale in the cataract districts of the Nile. On ascending Gebels Hormadjan and Eth Themmin, which border Wadi Isla, their summits were found to be composed of *coarse granite*, the biotite-gneiss being restricted to the lower slopes, indeed the whole of the Theman range appears to be of the former type, the quartz crystals in some instances being more than 2·5 mm. in length. A similar change from biotite-gneiss and hornblende-granite to coarse red granite is observed when the valley itself is ascended, a granite with large quartz, red felspar, and chloritized biotite taking their place. The hornblende-granite essentially contains colourless quartz, white felspar and dark-green hornblende, titanite being also frequently present according to Fraas. The rock is therefore similar to the granites of Aswan and the island of Philæ, as well as to that of Gebel Gharib in the Red Sea hills *.

Triple Rock Division in Sinai hills.

The succession noted in Wadi Isla is repeated throughout the greater portion of the Sinai ranges, the three rock-types above-mentioned being so frequently associated together that there seems to be some intimate connection between them. The granitoid gneiss and hornblende-granite appear to be the fundamental rocks of the central axis of the peninsula, the red granite being subsequent to these, and often shewing structures characteristic of intrusive bosses. Various localities may be taken as type-examples, to illustrate the relations of these holocrystalline acid and more foliated members to each other, any prominent variations in their structure or relation ships being also noted.

As already remarked, the striking feature in the neighbourhood of Wadi Isla is the fact that the summits of the ranges consist of the quartz-felspar granite, the biotite-gneiss occurring at the base; on the other hand, in ascending the valley no line could be drawn between the gneiss and granite, but at a certain point (St. VI. of the field-sheets kept in the Survey offices) the grey speckled gneissose biotite-granite commences to be replaced by the coarse red variety, the latter in many places containing but little quartz, or else quartz and felspar combined in about equal proportions. The red granite is often broken up by joints into large rectangular blocks, and is much veined by dykes of red granite and quartz. Further up the valley, the rock becomes more complex, broad basic bands alternating with fine-grained types of the quartz-felspar granite. Near the mouth of Wadi Um Arag there is a particularly fine example of one of the black dykes traversed by red granite veins.

The whole of the region drained by Wadis Eth Thebt and Tarfa appears to be essentially composed of the biotite-gneiss* which at the head of Wadi Tarfa *overlies and is intruded into by a red, very quartzose granite*, poor in mica, which also forms the main mass of Fersh Sheikh El Arab.

Distribution of igneous rocks.

Owing to the many minor variations in the rock-structures, it was impossible to obtain a clear idea of the relations of the main constituents whilst in the valleys, and it was only on ascending the commanding summit of Abu Mesud that an opinion could be formed as to the distribution of the igneous rocks in the neighbourhood. Here three types of country are clearly outlined. 1. A light-coloured granite region traversed by innumerable dykes forms most of the district immediately to the north of Wadi Nasb and at the head of Rahabeh, while south of Nasb N° 2, the darker green-tinted biotite-gneiss predominates. Though the difference is very distinctly marked when seen from above, it would be difficult to trace the boundaries of these two divisions from the valleys themselves, as a hornblende syenite,† which closely resembles the gneiss, is also present in the first-named

* The gneissose structure is in many cases so little marked that in the field-notes it is generally described as a biotite-granite.

† The hornblendic holocrystalline member is variable in mineral composition, and in the following remarks is described as hornblende-granite or syenite according as quartz be present or absent.

area, in which otherwise the predominant member is granite. The biotite-gneiss of the second division is in its turn penetrated by the bright-coloured red granite N° 3, which is widely distributed, and forms several distinct mountain groups, the base of the Abu Mesud plateau, and the high peak of Nakhara.

Graphic granite.

On leaving the plain of Rahabeh, Wadi Nasb is for a short distance in close proximity to the boundary of the above-mentioned regions 1 and 2, the first-named consisting as previously stated of the decomposing light biotite-granite traversed by parallel dykes, and the second being darker in colour, more complex in structure, and richer in hornblende. One of the tributaries, Wadi Hezaima, entering Wadi Nasb from the north, drains a district which is mainly composed of a coarse decomposing micaceous granite, in places *finely graphic*. This rock is continued in the prominent ranges of Abuksheib, Hezaima, and Beidha, giving the latter the very light colour to which it owes its name (Arab. the white mountain). A very noticeable feature is the weathering of this rock, deep hollows or caves having been formed in the boulders*. This may be due to several causes, especially the wearing away of the easily cleaved biotite, and the loosening of the coarse grains of quartz by the breaking down of the more readily decomposable felspars in the neighbourhood of the holes thus produced. The ranges of hills enclosed in the angle between Wadis Nasb, Um Ghirat, and Senned, appear to be composed of this biotite-granite, as a rule weathering in rounded masses, but the rock forming the summit of Um Beda is of a somewhat drusy character.

When Wadi Um Rachal enters Nasb, the geological conditions are much more complex, purple and green decomposing schists being intercalated in and alternating with an almost graphic granite, which as the valley is ascended is succeeded by hornblende-syenite, biotite-granite, and finally a banded granulite. The schists (having a sp. gr. of 2.72) are in reality a contact-alteration, being composed of quartz, hornblende, and magnetite, and are probably altered grits (N° 3453)†. The purple variety is on the other hand composed of quartz, felspar, and chlorite

* This feature in granite has of late aroused attention, and its origin requires special consideration and study. See Bonney, "Some eroded Rocks in Corsica" (Geol. Mag. N. S. Dec. V. Vol. 1. pp. 388-392, Aug. 1904), and Baron, "Rock Cavities in Granite of Madagascar," (Geol. Mag. Dec. V. Vol. II. pp. 17-21 Jan. 1905). Obviously the character is geographically widespread.

† A number in brackets thus ( ) indicates the number of the specimen in the Cairo Geological Museum.

with irregularly distributed brownish decomposition products, and numerous highly refracting zircon-like minerals. Its sp. gr. is much lower than the preceding, being only 2·57, but it also has all the characters of a metamorphosed grit. (N° 4814).

Speaking generally, the three main divisions already recognized in Isla seem to sweep in broad bands from west to east across the country, the coarse granite lying to the north, the hornblende-granite or syenite separating it from the biotite-gneiss which spreads over the southern portion of the peninsula. At the Gates of Nasb the crossing of the Um Raiyig-Shellala rift breaks the continuity, the triple division also being obscured by the vast number of dykes which seam the older rocks in every direction.

The presence of the Madsus schistose district also for a time obscures the relations of the underlying holocrystalline rocks, but these were again studied in the upper part of Kyd and its main tributaries. Here immediately west of the schist district, Gebel Gazala consists of coarse granite with scattered mica, much chloritized, while a little further to the south the rock is a very quartzose biotite-granite. In Wadi Um Gerat, a short distance from the junction of the granite and schists, gneisses are finely developed, occurring, however, in bands only a few metres thick, alternating with a deep-green or black hornblende schist. This highly foliated structure seems to be purely local, the gneissose character as a rule being somewhat obscure. The explanation which suggests itself is that broad bands of granite have penetrated between schistose beds, and the two have subsequently been involved in mountain-forming changes while the granite was in a plastic condition, or have been drawn out under the dynamometamorphic pressures. The acid and more basic members alternate, interdigitate or interfoliate in the most complex manner. In microscopic section the gneiss is mainly composed of quartz drawn out along the foliation lines, some felspars, and films of biotite, the specific gravity varying from 2·63 to 2·70. The basic member, on the other hand, is a hornblende-plagioclase rock, with a sp. gr. of 3·01.

Further to the west, the normal biotite-gneiss makes its appearance, this rock apparently overlying more schistose members. It is often rich in mica, is extremely friable, and contains quartz veins, which have been much folded and fractured. The fundamental rock is more difficult to determine in this district, many variations being noticeable. Gebel Geraui is mainly composed of schists and gneisses, which are sometimes granitic and at other times dioritic lithologically, the whole being traversed by thick bands of quartz-felsite, between which the

schistose beds often stand vertically, it being frequently impossible to assign a special foliation-dip to them.

The main mass of hills fronting the central range (Um Taibekh, Sahasia, and the Genaui-Mazeeh range) is distinctly composed of the biotite-gneiss with numerous dykes, while the central range itself seems to be the coarsely granitic rock, there being no evidence of a type rich in hornblende lying between the two. A series of cross-sections taken across the country show that the rock variations are divisible into certain broad categories related to one another.

On the latitude of Sabbagh the central range is still the coarse granite of Eth Thebt, while the foothills to the east (Um Ekhlis) are in the main the biotite-gneiss, these in their turn being succeeded by low hills, entirely composed of highly quartzose granite, which occupy all the remaining space between the gneiss hills and the sea. The true relations of these rocks is well shown in Wadi Yahamed, where the dark-blue biotite-gneiss is intruded into by the orange-red highly quartzose low-country granite. Still further south, on the latitude of Um Adowi, the central range itself undergoes a marked change, the coarse, red granite no longer occupying the central axis, but being replaced by a *hornblende-granite*, (with little quartz and much acicular hornblende) which forms both the mountain masses of Ethnarbi and Um Adowi, as well as most of the higher peaks of the central range in their neighbourhood, e. g. Aad, Sahara, etc. There is a still more interesting development in the spur of Haimar and Gebel Aad, the normal hornblende being in part replaced by the deep blue-green soda variety, riebeckite. This mineral was formerly mistaken for tourmaline by the writer, the long black acicular crystals recalling the latter in hand specimens, but Professor Bonney, who has kindly examined many of the Sinai micro-sections, has recognized its true character. Further to the east, the hornblende-granite is replaced by biotite-granite, in which a gneissose structure is locally developed, but is not usually well-marked. Finally, the hills bounding the coast plain are essentially composed of a coarse red granite, but with little mica or hornblende.

In the side-valleys of Wadi Awaja, the relations of the first two rock-members to each other are more clearly displayed, the maze of hills being composed in a somewhat bewildering manner of three types of acid rock. 1, biotite-gneiss, or granite with gneissose structure, whose components are of small size. 2, a medium-grained hornblende-granite, grey in colour, and 3, a red granite which does not appear to differ from No. 2 except in colour. The difficulty of identification is increased owing to the ready decomposition of the rocks, No. 2 being

especially prominent in this respect. Here the gneiss is apparently the oldest, and has been intruded into by the coarser and more quartzose members.

The sequence of these rocks near the Kyd-Madsus schist-region being given in Pl. XXI it will be unnecessary to enter into a detailed description of them. As a type of the whole, the rock-structures as displayed along the coast of the Gulf of Akaba may be now considered. Viewed from the camp at the mouth of Wadi Gnai el Atshan, the hills which rise steeply from the shore are observed to be very differently tinted, and an examination shows that these again fall into three distinct types: 1, hills composed of the light highly-quartzose granite, similar to that of the Gnai range; 2, a darker-coloured range, formed by a well-marked rock, showing distinct massive banding, this in the main being a biotite-gneiss, but with it being closely connected; 3, a hornblende-syenite or diorite similar to that found on the other side of the watershed. Passing southward, a sharp change takes place, distinct red and grey finely-banded gneisses forming the southern foothills.

The No. 1 granite gives rise to abrupt peaks and difficult summits near its junction with No. 2, while dolerite dykes penetrating it produce deep grooves separated by precipitous slopes.

Proceeding southward the hornblendic gneissose syenites are the main components of the cliffs as far as Wadi Waira, these being in places penetrated by basic and fine-grained felsite dykes, while the gneisses (much folded and contorted) appear to form a band bending inwards from the shore-line.

In Wadi Sajerat these become very fine-grained and smooth-surfaced, having an apparent eastward dip of about 30°.

Generalizing for the whole district, it may be stated that all the hills facing the sea appear to be composed of the non-quartzose hornblende-biotite syenite with large sphene, but whether ascending Wadis Mowila, Sajerat, or Um Ekhmoil, the result was the same, viz. this rock being succeeded by distinct grey or red gneisses. The latter series is often brightly coloured, the succession of green and red bands in it forcibly recalling a felsite and dolerite alternation, while the intermixture of a hornblende-biotite-gneiss similar to the syenite suggests that the whole gneissose series is the latter plus its dykes, very much crushed. It must, however, be admitted that the gneiss band is very well defined.

This triple division, which is constantly repeated, is evidently not an accident, but must be connected with important differences in the igneous rocks themselves, these being of regional value. In considering the question of their origin, attention may be called to a further striking

feature in the Sinai peninsula, giving rise to scenic characters of the first magnitude, as already shown it the section on Topography.

A study of the rocks commonly classed as metamorphic has led to their division into two groups, the one derived from "rocks of consolidation," or igneous rocks, largely characterized by their crystalline nature and coarseness of grain; the other schistose in character, derived from sedimentary and detrital formations. Both the groups are represented in Sinai, and illustrate the relations of a heated magma when brought into contact with a more ancient volcanic and sedimentary series. The result of this intrusion on the heated magma itself may first be considered.

Igneo-Metamorphic Rocks.

Varied theories have been suggested to account for the structure of the granites and gneisses included under the above term, and it will be easy to shew that several of these may be at once rejected, so far as Sinai is concerned. That the gneisses, etc., are not part of the primitive floor is proved by the fact that where they meet the superincumbent schists the latter have undergone distinct contact metamorphic changes.

Weinschenk (Congrès Géologique International Paris, 1900, Vol. 1, p. 340, *Sur le Dynamométamorphisme et la Piézocrystallisation*) has given an explanation which seems best to satisfy all the conditions observed, though there are some details which do not appear to be perfectly clear from his theory. "All study of this question tends to show definite relation between mountain-folding and the appearance of granitic masses. By the external pressure exercised during folding, the fluid magma rose from the depths, and was injected between strata of different geological horizons, while colossal movements and dislocations accompanied the phenomena of intrusion. The intensity of stress was not altogether abolished by the injection of the liquid magma, and the latter was consolidated under the mountain-forming pressures which still continued. The first minerals of consolidation are the dark minerals, hornblende and mica, the mica being the first-formed in the liquid mass. At this moment, the orogenic pressures acted on the peripheral zone of the magma, orientating the minerals normally to the pressure. In the heart of the viscous mass this faculty of orientation has been replaced by an internal stress acting in all directions. This is the explanation of a peripheral schistose zone shading into a granitic kernel."

Mr. Teall, in his Presidential address to the Geological Society, May, 1902, has put the matter very tersely when he says: "Thermo-metamorphism will not account for the facts, neither will dynamic metamorphism; but if we combine the two ideas, and recognize the fact that thermodynamic metamorphism may be associated with the intrusion of molten mineral matter and the formation of mixed rocks, we find ourselves in possession of a powerful intellectual weapon wherewith to attack many problems connected with this puzzling group."

This method is the one which must be used to explain the Sinai problem, the explanation here offered being as follows:—Dynamic movements (folding, etc.,) permitted of the intrusion of an igneous magma, which in places surrounded, cut off, and partly melted down portions of the overlying sedimentary mass (See Um Gerat gneisses, p. 66) while in other areas the latter only displays the more usual contact phenomena. Consolidation commenced with the formation of hornblende and biotite, the rocks near the junction being normally syenites or diorites, while the pressures have been sufficient to give the magma a slightly gneissose aspect. This outer peripheral zone was already somewhat resistant when a second pressure of greater power was transmitted to the interior portion of the solidifying magma, producing the gneisses of the interior zone. *

Newer red Granite and Igneous Dykes.

While this theory accounts for the granitoid gneiss and the hornblende granite, the ancient sedimentary and igneometamorphic complex appears to have been invaded at a later date by a very acid magma, and by a series of dykes which have been contemporaneous with the red granite masses or of later date. The red granite, which consists of quartz and dark-red felspar in equal proportions, other constituents being rare, plays an important part in determining the more salient features of the country. Its most extensive development is in the central range, where rising through the gneisses and ancient granites, it forms the precipitous crags of Serbal and Um Shomer, the long knife-edges of Rimhan and Theman, the bold summits of Eth Thebt and Sabbagh, finally disappearing in the low country near Wadi Budr.*

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* Its extension south of Sabbagh was determined through specimens brought by Herr Guyot from Wadi Budr. The watershed must have originally followed this granite ridge, and still follows it to-day. (See p. 17).

A similar ridge culminates in the peak of Derawi, and several of the smaller ranges above Nasb are also of the same character.

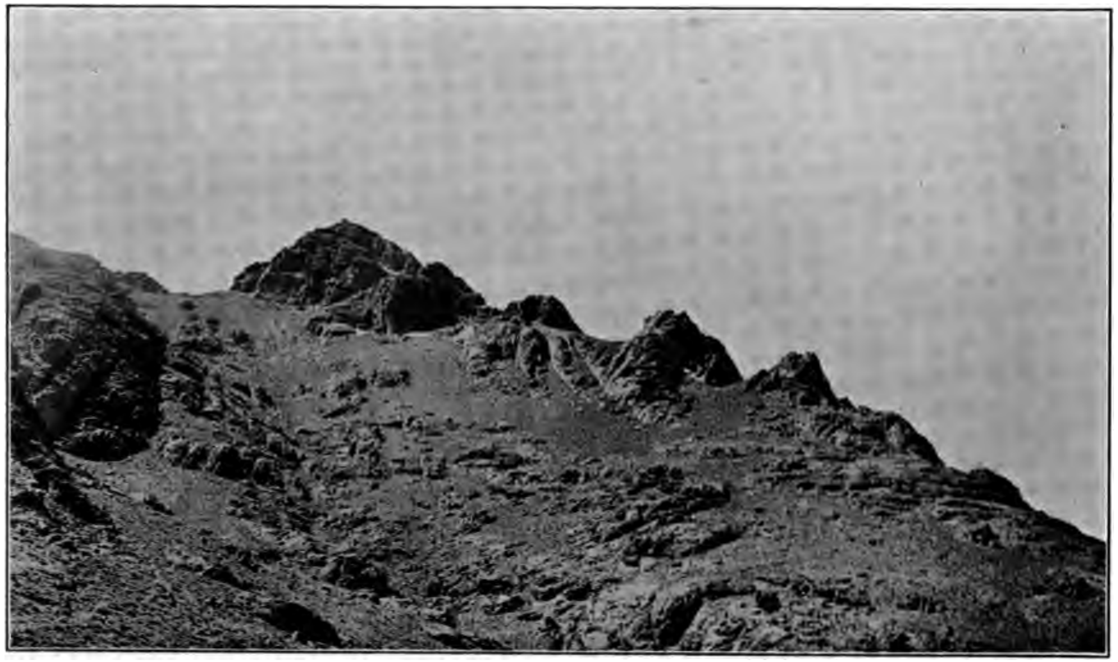
In some cases the red granite has risen in gigantic bosses, giving rise to steep mountains with rounded summits, exemplified by Gebel el Deir opposite Gebel Musa, or again forms much of the low country near Wadi Nasb, etc., though nearer Sherm the granite in the foothills is rich in porphyritic felspars, and probably represents the more acid portion of the rock series described in the previous section. To the north of Wadi Nasb the areas occupied by the gneisses and red granites are sharply marked off from one another, differing in colour, and to a certain extent in surface features; thus the true granite country is usually more rugged and has a distinct and characteristic red shade. Quartz and orthoclase are the characteristic minerals, but in some localities muscovite mica is a common constituent, especially where the granite borders the schist region at Gebel Naba. The presence of graphic structure has already been mentioned.

Igneous Dykes.

One of the most striking features in Sinai is the remarkable banding produced by variously coloured dykes, which seam the mountains and cross the highest peaks, preserving a perfect parallelism to each other, which persists over many kilometres. Even before Wadi Isla is entered, the small ridges which cluster at the foot of the higher mountains are observed to owe their origin to dykes mainly trending in a north-north-east and south-south-west direction, and in the high ranges of Shiddok and Emlaha, the red and dark bands pass over the main crest. These veins practically extend throughout the whole igneous region over many kilometres without any perceptible break in their continuity, and by their superior hardness determine the directions of many ranges. When composed of basic rocks, they often produce gullies, which not infrequently form the only road by which some of the steeper scarps can be ascended.

These dykes are of almost every petrographical variety, from the coarse quartz-felsites and fine-grained felsites, which are more commonly found in the granite regions, to the dark dolerites and spheroidal diabases * which in the metamorphic areas are sometimes so crowded as completely to mask the schistose rocks enclosed between them. They are clearly the youngest members of the igneous series, as every other

* One of these rocks in Wadi [illegible] consisted of fine-grained augite, magnetite and chlorite.



FORMATION OF DYKE SUMMIT, GEBEL KATHERINA.

type of rock has been penetrated by them, but as has been previously remarked, none of them have been noted passing into the Nubian sandstone, which rests upon a plane cutting them off abruptly. In Eastern Sinai, at any rate, all the dykes appear to be pre-Cenomanian, and judging from the neighbouring regions, probably pre-Carboniferous also.*

Duplicate system of dykes.

While the general trend of the main system of dykes is north north-east and south south-west there is frequently a second system, generally roughly at right angles, which occasionally shows marked differences though these are not sufficiently constant to establish any general rule. In the slopes of Abuksheib, above Wadi Nasb, a north-west to south-east trending group consists of basic dykes which have shifted the acid and basic members of the principal series, and are consequently of younger age. Two may also cross each other, giving rise to X-shaped forms such as are developed in Wadi Letih, or to an interlacing mass of dark veins, there being a beautiful example of this class in the hills near Dahab.

Thickness of dyke.—The dykes vary considerably in thickness, sometimes being only a few centimetres wide, while more commonly they vary from the ten-metre bands of Isla and Beidha to the huge green dyke, 100 metres broad, which runs steeply up the granite slope opposite Gebel Jeraimda, near Dahab.

Among the rocks in the hills west of Dahab a marked dyke of satiny lustre with sp. gr. 2·62, which extends from Gebel Moghtut to Jeraimdeh, is a *porphyrite* having an angular intergrowth of red felspar still showing parallel cleavages, and fibrous chlorite derived from hornblende. Another of these rocks of sp. gr. 2·57 is closely related to a *Bostonite*, but is more coarsely crystalline, and with a chloritically altered ferro-magnesian silicate between the lath-shaped felspars, hornblende also being present.

While the above remarks illustrate the main rule with regard to dyke occurrence, exceptional conditions have been observed. One of these occur in Wadi Isla, where some of the black doleritic dykes have

* The above remarks only hold good for the dykes in Eastern Sinai, in the west the fine dyke in Wadi Tayiba clearly shows that intrusions have taken place at late dates into the Nubian sandstone and younger beds, while many such have been noted by the writer in the Nubian sandstone between Dongola and Halfa.

been pinched out, leaving fragments enclosed in the gneiss. This character taken by itself might suggest that the gneiss was younger than the dolerite, but it probably owes its origin to changes produced in the gneiss during the intrusion of the dolerite. It has indeed, been shown that the heat of the intrusive mass is sufficient to melt the neighbouring rock, differential changes being produced which give rise to apparently contradictory results.* Near the mouth of Wadi Um Arag, there is on the other hand, a very fine example of a black dolerite traversed by red granite veins, showing that the acid rock was in this case of distinctly later date.

Viewed from the summit of Tellat el Gimal, the dykes are seen to vary in their direction of trend, those to the north-east of the peak having a north-west to south-east strike, while to the west they as a rule extend 10° south of west. In this connection it may also be remarked that quartz veins are of frequent occurrence, at the foot of Abu Mesud carrying hæmatite and iron ochre at the surface. The same mineral is very abundant on Gebel Tha'albi in veins and pockets, a hydrous mica also being developed is radiating fibrous masses on the surface of the rock.

Spherulitic felsites.—In his notes of specimens collected by Professor Hull, Mr. F.W. Rudler † described a spherulitic quartz-felsite from a dyke in Wadi El Araba. This rock was of a chocolate or liver-colour, in this respect differing from felsites of a similar nature which are of frequent occurrence in Eastern Sinai. On Gebel Um Zaimer the dykes are mainly syenite-felsites, quartz being comparatively inconspicuous. Among these is a handsome red rock with white porphyritic felspars and a darker variety with white orthoclase felspars of greater size, the basic material having possibly come from considerable depths and brought larger crystals with it. A banded spherulitic rock was also present near the summit, and a compound dyke, a purple porphyry forming a band on each side of a quartz-felsite. It has been a difficult question to decide whether the quartz felsites are in all cases subsequent to the red granite, dykes of this kind which penetrated the schists near Wadi el Tema apparently ending at the edge of the granite.

In general, however, the quartz-felsites are certainly younger than the main mass of the holocrystalline member. For instance, in the schist district of Um Zerig a fine-grained quartz-felsite was observed

* See for instance, Parkinson, Q. J. G. S. 1900, and Sollas. Trans. Roy. Irish Academy.

† (Professor Hull, "Survey of Western Palestine," Appendix B).

filled with rounded fragments of granite and portions of the fine-grained schists, showing that it had traversed both these rocks. On the other hand, on Gebel Um Malaga, which consists almost entirely of the coarse, easily decomposing red quartz-orthoclase granite with hornblende (usually much altered), it was observed that this rock was traversed by abundant veins of dolerite, but no quartz-felsites were visible, this observation tending to the view that these acid holocrystalline and dyke rocks originated at the same period.

CHAPTER XII.

ON THE EVIDENCE CONCERNING CONTACT CHANGES IN A SEDIMENTARY AND VOLCANIC AREA BY THE INTRUSION OF AN IGNEOUS MAGMA.

It is evident from the above remarks that the metamorphic rocks of Sinai fall into two well-marked divisions, an *Igneous* series showing foliation, in which gneissic structure is produced in an igneous magma along the lines previously described, and a *Detrito-Metamorphic* series, including changes produced in sedimentary or volcanic materials by the action of a heated plutonic mass injected in a fluid condition. The differentiation of the detrito-metamorphic rocks is more difficult than that of the lighter igneous members, owing to their uniformly dark colour and intense penetration by basic dykes.

On entering the mountain region it was noticeable that the summits of many of the highest peaks of the peninsula were darker coloured than their granite neighbours, owing to their being capped by rocks of a different character. A subsequent examination of the peaks of Abu Mesud and Ekma showed the capping to be due to a felsite or andesite of dead black colour, containing small scattered porphyritic felspars. This rock doubtless also forms the summits of Zebir, Nakhala, and Khasib, which though not personally visited, bear the strongest resemblance to those above mentioned.

At the junction of Wadi Um Rachal, the purple and green schists already described on p. 156 were the first evidence obtained of the presence of an ancient *sedimentary* series, which further east in Gebel Ferani was represented by a fine-grained green slate penetrated by

Microscopic sections of these rocks, which have a sp. gr. of 2.75, show them to contain granular quartz and hornblende, their characters being those of a grit which has undergone contact alteration. A similar schist from Wadi Kyd in section proved to be a fine-grained variety, having a sp. gr. of 2.75, and consisting mainly of quartz, green fibrous hornblende, and magnetite. It was traversed by a vein of epidote.

Changes towards contact with granite.

On ascending Wadi Kyd from its junction with Wadi Ethmoi the beds are alternating "hornfels" and phyllites, but as the granite is approached, mica schists predominate, gneissose types increasing, until finally a *hornblende-schist* extends to the boundary of the granite itself, hornblende-felsite dykes at the same time increasing in importance and numbers. The granite (really a gneiss), a coarse variety with biotite, has a sharp vertical junction with the schists, which are tilted at a high angle on approaching the intrusive mass.

Southward of the Ethmoi-Kyd junction, ascending Wadi Zerig, the contact changes are of a different nature, the spotted slates, etc., apparently passing into an *andalusite-schist*, which contains large crystals of andalusite showing the characteristic pink pleochroism, and flakes of biotite mica, the remainder of the ground mass consisting of a mosaic of quartz.

Returning to the western junction of the granite and schists, the contact at first corresponds with the lower portion of the great tributary of Wadi Um Gerat, where its characters were well displayed. The schists are seen to be dipping at high angles near the margin of the granite, their schistose character being preserved up to the point of contact, and also in the numerous fragments enclosed in the granite, in none of which is there any direct evidence of contact metamorphic changes. Small sills of the acid rock extend from the main mass into the schists, but only one vein 7.5 mm. in breadth was noted, the remainder not exceeding 12.5 mm. The intruding rock at this point presents no special feature, being a coarse, very quartzose biotite-granite. Ascending Wadi Um Gerat, a short distance from the junction of the granitoid gneiss and schists, are the true gneisses (sp. gr. varying from 2.63 to 2.70) previously described on p. 157. This highly foliated structure appears to be purely local, the gneissose character otherwise being as a rule somewhat obscure.

From the southern bend of Um Gerat, the intrusive mass is represented by a biotite-granite, apparently overlying the schists, which are rich in mica, very friable, and containing quartz veins, the latter often much folded and fractured.

Following the contact southward, the junction of the normal schists and gneisses was again observed in Wadi El Tema, where the granite magma has been squeezed between the schistose strata with the result that biotite-gneisses and mica-schists are intimately mixed. Further complexities are introduced by the presence of numerous dykes such as the fine-grained red felsites trending in the usual north-east direction, the main ridge of Gebel Samra* being also composed of a highly magnetic dolerite dyke, while veins of diorite are also frequently noticeable.

The schists themselves appear to form portions of a dome, the beds varying constantly in their dip, there being a complete reversal passing southward from a strong north-east dip to one of 26 degrees south-east. In this neighbourhood the dykes of felsite are clearly seen to pass from the granitoid gneiss into the schist.

From this study of the western border it is apparent:

(1) A *biotite-granite* has been intruded into a *sedimentary series*, consisting of grits and argillaceous beds, possibly associated with volcanic ash.

(2) These sedimentary beds display varying characters according to their distance from the invading magma, those furthest removed being compact fine-grained hornfels, or spotted slates, etc., whilst nearer the junction are mica- and hornblende-schists on the one hand and andalusite-schists on the other.

(3) In Wadi El Tema the acid magma has been interfoliated with the schistose laminæ, producing a *lit-par-lit* structure, mica-schists and biotite-gneiss alternating. These have been frequently referred to under the name of mictosites.

(4) The schists have undergone disturbance, the direction and amount of dip varying greatly.

On crossing the low camel-pass which separates Wadi El Tema from Wadi Gebila, the biotite-granite and schistose constituents are seen to be intimately mixed, the former having been foliated in a striking manner, and in many places enclosing portions of the schist. The junction is soon crossed, hornfels squeezed in between dolerites and

* The summit of Samra is formed of an old felsite with quartzose matrix, and very decomposing crystals of orthoclase, with possibly plagioclase felspar as well. There is a little epidote. Sp. gr. 2.65.

mica-syenite-felsites taking the place of the mictosites. In a rapid traverse made across this district from east to west, the characteristic feature noted was the enormous development of acid and basic dykes, rendering an examination of the contact metamorphic changes difficult. On crossing the second Gebila pass to descend towards the Gulf of Akaba, the igneous rock is again met with, here being a biotite-syenite, of a deep-red colour near the junction itself, but shading into a grey variety seaward; * the sedimentaries at the base of Gebel Atshan are on the other hand of the hornfels type, towards the summit becoming very micaceous, and contain conglomerated fragments of dolerite.

On the southern side of Wadi Gebila the relations are somewhat different, the red rock near the junction being a granite very rich in quartz, but in the valley large blocks of a quartz-syenite had been observed, in which the crystals of hornblende were over 10 mm. long, and of a fibrous green variety. The more acid magma appears to be the later, as it also contains fragments of the syenitic rock where the two come in contact. The junction of the sedimentaries and red granite is of interest, the former continuing their regular dip up to the point of contact with the granite, which rises in vertical bands. Great dykes of dolerite traverse the schists giving rise to the rugged outlines of many of the mountains, while the schists themselves are so broken up that they display few hand-specimen characters, and it is doubtful whether sections would reveal their true nature. In addition the dykes themselves have become foliated in places, mica having been developed along the lines of easiest fracture.

The southern border of the schist area in Wadi Kyd is only a further illustration of the fact that a granite magma has penetrated an older sedimentary and volcanic mass, a mixture of mica-schists, granulites, and dolerites having clearly undergone differential movement, the schists being in places pinched in between the granulites, and giving rise to small overthrusts; the boundary between the granite and schistose area is at the same time very sinuous, and the dip variable, mainly southward but eastward in Wadi Tarr.

On re-entering the schist region at Wadi El Beda, the fundamental rock noted was the compact grey rock or hornfels, this being far less conspicuous than the dykes of purple andesite and dolerite which give rise to ridges separating steep boulder-strewn gullies. Many of these contained rounded fragments of granite, showing them to belong to the latest of the igneous intrusions. The rocks of a schistose character

* This rock has sp. gr. 2.73, and in section is a hornblende-granite with sphene.

here occupy a very secondary place, the compact grey Khlalat hornfels being the conspicuous member.

On the return from Ras Mohammed, the contact metamorphic area was again entered at the point where Wadi Beda joins Wadi Kyd. Here the schistose characters are completely obscured in the dark and frowning hills dominating the valley by the dolerite dykes which with their massive jointing are everywhere conspicuous. Where Wadi Madsus joins Kyd, we are in the very centre of the metamorphic region, and though the schists show considerable variation in detail, it is possible to note some broad differences, the strata being often glittering slates on the summits, while below they are darker and more micaceous, indicating closer proximity to the igneous magma. Some of the more prominent peaks (Madsus and Ethmoi, for example) are composed of semi-gneissose irregular-layered schists, which may be mictositic in their nature. The abundance of dykes* adds to the scenic complexity, the red felsites trending north-east throughout the schists, while dolerite dykes give rise to the principal precipitous ridges.

That the acid magma is never far from the surface is shown near the mouth of Wadi Amlagh, where it appears in the form of a syenite, soon again disappearing under the schists, which here overlie it in thick layers, and dip in varied directions. From one station they were seen to be dipping northward to the north, eastward to the east, and westward to the south, there being also a good deal of minor folding.

At the mouth of Wadi Sai'amin (see Pl. XXI) the contact is again clearly visible, the schists near the junction being intensely hornblendic, and massively bedded. The range of Gebel Boutroiya, which represents the intrusive element, is lithologically a syenite, but is here distinctly gneissose, and appears to have been forced in films between the schistose layers.

The following field-note written on the summit of Boutroiyeh, contains practically the main truth as to the whole district. "All the hills between Adakkar and Sai'amin appear to be of this character, viz— granite (in reality quartz-diorite) mountains simply plastered with schists, Adakkar, Um Zaimer, Hamra Er Rahab, and the present station, all seeming to form a group of mountains just released from their schistose covering. In Wadi Adakkar the schists are dipping north-north-west at their junction with the gneiss, which either meets them in a vertical plane, has been faulted against them, or thrust over and between them.

* On the side of Madsus is a felsite of sp. gr. 2.62, having a microcrystalline base in which are scattered crystals of plagioclase felspar and biotite.

The gneiss is characterized by steep and precipitous slightly rounded slopes, with a dark green tinge absent in the granite, on the other hand the schists give rise to long smooth slopes, glittering in the sunshine, and sloping according to the particular angle of dip." *

This portion of Eastern Sinai is particularly complex (see Pl. XXI) no less than five distinct members playing an important part in its structure. In the first place there are the two series whose characters and relations have just been considered, viz., the gneissose syenite and the metamorphosed sedimentaries; in the second the volcanic rocks of the Ferani range, also underlaid by the syenites. In addition there is the younger red granite of Malaga, which meets the schists in Gebel Naba, where it becomes very rich in muscovite mica. Wadi Naba is lined by schists and gneisses, the latter having sp. gr. 2·63, and possessing a granulitic structure. The component minerals are quartz, orthoclase and muscovite.

The contact-alterations were again noticed when descending Wadi Madsus, the Amlagh syenite being succeeded by bedded micaceous schists, weathering in thin flakes, plates and slabs. Though towards the west traversed by dykes of diabase and felsite, these become much more numerous to the east, red felsites and dolerites giving rise to important and precipitous crags. Ascending a station marked on the map XXVII, it was observed that the schists were mainly micaceous, in some places containing small brown-red garnets, though these in general were not perfectly formed. On the eastern side of the station the spots in the imperfectly developed schists are drawn out into long almond-shaped masses.

Of the rock specimens microscopically studied several have been obtained from this district. One of these from Gebel Akhmara (No. 3,426) had a sp. gr. of 2·91, and is mainly a quartz-mica-schist with garnets and tourmaline. The garnets show a tendency to rectangular outline, but are cracked and contain many cavities. The mica is somewhat drawn out, of green tint, with slight pleochroism and many dark spots round the inclusions, while the quartz is minute and granular. White mica is also present, and the tourmaline is in the form of small prismatic crystals of light colour, but showing strong absorption, straight extinction, and a marked transverse cleavage. On the other hand, one of the dykes forming the summit of Gebel Madsus has a sp. gr. of 2·66, the porphyritic crystals present in it being in

* In a section these schists prove to be aggregates of quartz and biotite. The rock at the base of Gebel Ethmemia had a sp. gr. of 2·77.

many cases plagioclase felspars, while the whole rock has a tendency to foliation.

The gneiss of Boudroiya has a sp. gr. of 2·68, and contains quartz, orthoclase felspar, biotite mica, sphene, hornblende, and apatite, so that lithologically it is a hornblende granite, but the quartz is not abundant. This acid character disappears further to the west, the hill masses to the west of Wadi Rahab (Um Retemi, Abu Lassaf) being much altered quartz-biotite-diorites, with a sp. gr. of 2·74. A similar rock occurring at the base of Gebel Sai'amin, with sp. gr. 2·76, also contained plagioclase felspar, interstitial quartz, and hornblende (altered in places to chlorite) the quartz-diorites thus having a wide extension at this point.

At the junction of Wadis Madsus and Melhadge the schists are again hornblendic, but in the Arabi or Ghrabi range to the east these are entirely obscured by the abundance of dykes of gabbro and red felsites, the latter often very fine-grained and without quartz. The sides of these mountains are steep, and covered with talus of readily-rolling materials which obscures their structure, while the crests are normally knife-edge ridges due to dykes.

Further north, in Gebel Um Zaireh, the base of the hill consists of dark mica-schists, having sp. gr. 2·75, and mainly composed of biotite-mica and plagioclase felspar, with a small amount of interstitial quartz. In ascending the hill, these are succeeded by glittering close-bedded micaceous schists, the highest point of the mountain being formed of a remarkably fine-grained grey rock of sp. gr. 2·68, which in the field-notes is described as possibly granulitic. This may be an extreme variation of the grits which evidently played the major part among the rocks of this region, but its origin is still open to dispute.

To the north of this hill there is an abrupt change, the dark-coloured schists being sharply differentiated from a grey massive hornblende-biotite granite, forming all the bordering low hills, which owe their lower altitude to the more rapid weathering of the granite. The granite in its turn is succeeded by the much-decomposed gneissic series already referred to (see p. 159 and Pl. XXI), the gneiss which is almost schistose and hornblendic, being thrown into small V-shaped folds. Associated with the gneissose series is a rock which, had garnet been present, could have been termed an andalusite-granulite, andalusite being a prominent constituent.

Summary.

A study of this dark schistose region reveals that it is formed of a series of ancient sedimentary grits, clays, volcanic ashes and tuffs, which have been invaded by a granitic magma, the chief minerals produced near the contact being *hornblende* and *biotite mica.* Such a change implies the former presence of a basic volcanic ash or tuff, which alone could supply the materials necessary for the formation of the ferro-magnesian silicates. The field relations, however, suggest that there is a progressive diminution of these silicates in the rocks, dependent on their distance from the contact, and point to a concentration of the basic portions of the sedimentary zone in the part which has been subjected to the highest temperatures. The hornblende as a rule occurs nearest to the igneous rock. In rare instances other products of thermal metamorphism are observed, a banded rock at the foot of Gebel Zerig being rich in *andalusite*, while *garnet* is also not an infrequent constituent. Where the pressure of the igneous flow has been parallel to the bedding of the sedimentaries, an interesting series of "mictosites," or gneisses due to interfoliation of the granite and the now schistose clayey beds, have resulted.

Other contact metamorphic areas.

Though specially developed in the above well-defined area, there is strong evidence tending to show that these sedimentaries were once far more widely distributed over the whole of Sinai. Postponing the consideration of the volcanic Ferani series for a separate section, several other schistose areas are present in the peninsula, the most notable of these occurring in the north-east angle formed by the junctions of Um Raiyig and Nasb (see Pl. XXII). On ascending Gebel Hedjan el Gimal from Wadi Um Raiyig, striped schistose rocks were observed standing at high angles and dipping eastward, enclosed between the ridges of hornblende-felsite and dolerite which give rise to the long talus slopes of the hill. These are still more conspicuously developed in the lower country to the east, where they are almost vertical or dip steeply at about 70 degrees south-east. A specimen of grey slaty nature, and sp. gr. 2·72, proved to be a contact-rock containing fine-grained quartz, hornblende and magnetite, the whole being, as in the previous case, apparently an altered grit.

The Um Rachal grits have already been mentioned, but in the southern portion of the peninsula there is also evidence of the former

presence of these ancient sedimentaries. This is the case in Wadi Moyyat El Aad, where schistose rocks, consisting of a fine-grained mass of quartz, biotite, hornblende, and abundant sphene, occur intermixed with the porphyritic grey biotite granite (in reality almost a syenite), which forms the base of Gebel Aad. In Wadi Letih, near the Gates of Letih, there is an interesting intermixture, the granite at first enclosing fragments of a finer rock, while further up the valley there is a small exposure of dark schists and red quartzose rocks dipping at 45 degrees. The presence of hornblende-granites in this neighbourhood suggests by analogy that the schistose covering was formerly of wide extension in this region.

Ferani volcanic series.

Hitherto the true sedimentary beds have in the main been considered, but in the Ferani range volcanic rocks of ancient date are closely associated with the grits above described. When issuing from the gates of Nasb, the foothills of the Ferani range were noted as being composed of an alternation of green and red rocks, the former resembling whetstones, while the latter were quartz-felsites. On ascending Gebel Ma'in the summit was found to be composed of a coarse conglomerate of felsites and dark compact igneous rocks cemented together by a matrix having the characters of a biotite-granite, and it was further observed that the felsites greatly resembled those of the porphyry ranges of Dokhan, on the eastern side of the Red Sea. At the base of the hill a similar conglomerate was in the main composed of highly banded rhyolites. The subsequent examination of the range in detail has borne out this conclusion, viz:—that great volcanic activity was associated with the deposition of these sedimentaries, the whole combination having been subsequently invaded by a granitic magma. Reversing the process by which this conclusion was arrived at from a study of the details unrolled in succession during the traverse, the details will here be considered in the light of the conclusion.

It has already been noted that the main summits of the Ferani range are composed of rocks which in hand specimens were apparently of andesitic nature. To confirm this point fragments were obtained from all the principal peaks and sections have been cut from these and examined. From this study we learn that the summit rock of Um Aleg is an ancient lava with corroded quartz and much-altered felspar in a cloudy base; that of Zaraga, on the other hand, is a re-sorted ash, made up of fragments of quartz, decomposing felspar, and pieces of

granophyre enclosed in a dusty base, the specific gravity being remarkably high, 2.69. In the lower slopes of the same hill is a devitrified rhyolite (sp. gr. 2.59) with microspherulitic and fluidal structure, an interesting point as suggesting that the acid preceded the more basic outflows. A similar rock at the foot of Abuksheib in Wadi Um Harag is also a spherulitic quartz-felsite or devitrified rhyolite.

In the lower range of Ma'in to the east of Ferani the volcanic rocks are of equal importance, the summit of Gebel Um el Wijera being composed of a devitrified fluidal lava (sp. gr. 2.65 to 2.69) with micropegmatitic base and porphyritic crystals of altered plagioclase felspar. On the other hand, the acid rock which forms the intruding member is an altered hornblende-granite, the constituent minerals being large quartz, altered felspar, hornblende, and much fibrous chlorite. The succession noted in the field-book from the base of El Wijera was as follows: The granite much traversed by diabase dykes, extends only a short distance up the hill, following on which are syenite or diorite-felsites, giving rise to a series of ridges. The peak of Um El Wijera itself consists mainly of two types of dark andesite, which also form the whole crest, the junction with the biotite-granite being at the foot of the hill. From Wadi Ma'in the succession is similar, with the exception that the granite is succeeded by a fine-grained quartz-diorite, itself intimately associated with the dykes (these including quartz felsites, hornblende-felsites and porphyrites, together with spheroidal diabases).

The following entries extracted from the field notes give the general impression formed by further examination of the ranges shown in Pl. XXI. These are in diary form.

11.4.99. "Ascended Gebel Lij, which consists mainly of felsites of the dark type, together with quartz-bearing varieties. The biotite-gneiss is present in a small basin near the summit, and also occurs in huge blocks in the boulders which fill the steep valleys on the side of the mountain. But the most curious feature is the presence of masses of coarse granite, standing like boulder heaps on the summit, and forming bold precipices on the sides. The one forming the main peak is really a very coarse quartz-felsite, in which idiomorphic orthoclase crystals are conspicuous."

12.4.99. "Wadi Um Harag traverses the felsites, most of these being fine-grained types. Gebel Um Harag and Gebel Ferani are composed to a large extent of andesites,* containing many fragments,

* In the original notes described as darker felsites.

apparently also felsitic. Through these rise quartz-felsites trending in the usual north-east direction. An interesting occurrence is the presence of what appeared to be undoubted contact schists high on the slopes of Wadi Ferani."

From the above observations it would appear that at a very early date (by resemblance with similar rocks in other countries, possibly late Archean or Early Cambrian) volcanic activity had been highly developed in Sinai; the acid lavas possibly preceding the more basic members. An acid magma subsequently invaded the whole complex, the portion nearest the contact becoming a gneissose quartz-diorite, and in some instances breaking up the felsites, etc., to such an extent that the two rocks are now closely intermixed.

Volcanic rocks are not limited to the Ferani range, being also present on the summits of many other important ranges. Abu Mesud, Nakhala, Khasib, and Ekma owe the dark colouring of their peaks to the presence of the Ferani andesite, which was also recognized in the downwash on the slopes of Gebel Katharina. In a rapid passage through Wadi Zagara under Gebel Habshi, a schist country was traversed, and there is little doubt that this mountain is like the Ferani range largely of volcanic origin.

Summary of History of Eastern Sinai.

Summarizing the observations recorded in the foregoing pages, the following are the conclusions which present themselves. The earliest chapter unrolled reveals a period of sedimentation and denudation, accompanied by intense volcanic action which spread its influence not only over Sinai, but also over wide areas in Egypt and the Sudan. Of this period no fossil remains have as yet been obtained, and indeed their presence would be surprising as the whole of this early sedimentary and volcanic region has been penetrated from beneath by masses of acid igneous rocks, granite and its allies, which have induced contact metamorphic changes in the sedimentaries, and themselves have been rendered gneissose and dioritic near the zone of contact. These in their turn have been invaded by red granites and dykes of the most varied description, the latter arranged in strikingly symmetrical lines which to-day traverse the whole country in well-marked directions.

All these complex events occurred before the deposition of the first fossiliferous limestones and sandstones of Carboniferous age on the denuded surface of the ancient continent in Western Sinai; though

these marine strata, the only records of a brief episode before the continental conditions may have once more gained the ascendant, are absent in Eastern Sinai. Of the life during the periods of the Permian, Triassic, Jurassic, and earlier Cretaceous, elsewhere marked by so varied and characteristic a fauna, there exists no trace, and only with the Upper Cretaceous (Cenomanian) does Sinai once more sink beneath the waters of that mighty ocean which spread far and wide over both hemispheres.

In this region the granite was planed down and the Nubian sandstone deposited on the plain of marine denudation, unbroken by the dykes, which though abundant in the granite, are cut off abruptly at their junction with the sedimentary rock. The sandstone, at the base brightly-coloured, ferruginous, and false-bedded, changes above into a great thickness of white, friable sands, themselves underlying marls and limestones containing a typical Upper Cenomanian fauna.

Further continuation of the history must be sought in the unstudied plateau to the north, the pages that record the Eocene and Oligocene being entirely absent in South-East Sinai itself, while only in the extreme south-east, the great oysters of Khoraiya show that the Miocene sea once spread round Ras Mohammed.

With the early Pliocene closes the period of quiet depression and deposition, or elevation and denudation, and instead we enter on a time of storm and stress, of mountain formation and gigantic fracture, which have left their mark both in chaotic confusion and far-reaching regularity. Up the broad trough thus produced advanced the invading Erythræan fauna, and the record closes with the silent witness of the coral-reefs to the gentle differential movements of to-day.

APPENDICES

APPENDIX I.

METEOROLOGICAL OBSERVATIONS TAKEN IN SINAI, BY Mr. H. G. SKILL, F.R.G.S.

Total 850 readings with analyses by Dr W. F. Hume.

Observations for October, 1898.

Date		Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898						
Oct.	16	7.20 a.m.	19·7	758·5	Seaside at Tor	....
"	"	noon	30	759·3	do.	....
"	"	6.40 p.m.	25·9	757·8	do.	....
"	17	7.15 a.m.	15·6	758·2	do.	....
"	"	noon	27·8	758·8	do.	Slight breeze.
"	"	5.20 p.m.	20·7	757·6	do.	No wind.
"	18	6.35 a.m.	19	757·8	do.	Fine.
"	"	12.40 p.m.	28·1	759·1	do.	....
"	"	6.15 p.m.	25·5	758·3	do.	....
"	19	6.30 a.m.	20	758·8	do.	....
"	20	7.— a.m.	16·8	758·4	do.	....
"	"	5.— p.m.	36·6	747·3	In Qa'a plain	No wind.
"	21	8.— a.m.	29·4	747·7	do.	Fine, still.
"	"	noon	36·9	739·2	do.	do.
"	"	2.5 p.m.	38·1	725·8	do.	do.
"	"	6.15 p.m.	29·2	728·2	do.	....
"	22	6.30 a.m.	28	728·3	do.	Fine: no wind as yet.
"	"	3.20 p.m.	28·9	717·2	In Wadi Isla	....
"	"	4.30 p.m.	33·3	723·2	Mouth of Wadi Isla	....
"	"	6.30 p.m.	27·2	722·9	do.	....
"	"	11.— p.m.	25	722·7	do.	....
"	23	2.— p.m.	32·8	703·6	Camp in Wadi Isla	Fine: no wind.
"	24	7.20 a.m.	25·6	704·1	do.	....
"	"	1.20 p.m.	26·1	622·6	Summit Gebel Eth Themnin	....
"	"	7.— p.m.	23	704·2	Camp Wadi Isla	....
"	25	7.— a.m.	25·6	703·8	do.	Fine: no wind.
"	26	6.— p.m.	23·9	673·5	Mouth of Wadi Rimhan	Fine, still weather.
"	27	6.— a.m.	17·8	674·2	do.	Fine, still.
"	28	7.45 a.m.	18·9	673·5	....	....
"	"	11.25 a.m.	23·3	...	Summit, spur of Humr	No wind.
"	29	8.— a.m.	22·4	673·3	Mouth of Wadi Rimhan	Fine: still, some cloud.
"	"	?.6 p.m.	16·7	635·2	Head of Wadi Tarfa	....
"	30	6.— a.m.	14·4	634·3	do.	Beginning to cloud towards evening.

Observations for October, 1898 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Oct. 30	9.50 a.m.	11·5	...	Summit of Gebel Fersh Sheikh El Arab	....
„ 31	6.50 a.m.	17·2	633·7	Head of Wadi Tarfa	Heavily clouded with gusts of wind and drops of rain increasing towards night.
„ „	12.30 p.m.	25·5	633·9	do.	
„ „	5.25 p.m.	19·9	633·4	do.	

The second half of the month of October, 1898, in Sinai was in general hot and still, the maximum recorded being in the open plain of El Qa'a at 2.5 p.m., viz., 38·°1,* and the minimum preceding the storm period, viz., 14·°4 at 6 a.m. on the 30th. The storm of the 31st first appeared from behind Gebel Eth Thebt, heavy white clouds rolling up from the south-west. Later it divided itself into two divisions, the one advancing westward of Wadi Tarfa along the Rimhan-Um Shomer crest, and the other following the main watershed from Gebel Tarfa to Fersh Sheikh El Arab. By this division the camp itself escaped much rain, though there was a constant succession of thunder-peals and vivid lightning throughout the day, and the Arabs reported a "seil" or torrent in Wadi Wa'era to the east.

Immediately on entering the mountain gorges, the greatest care was exercised by the sheikh as to the selection of camps, there being but few places in safe positions in these deep valleys. From the above figures it will be seen that the days of maximum heat were from the 20th to 23rd, in the plain of El Qa'a and lower part of Wadi Isla.

The averages for the principal hours are :

Morning, 6 to 8 a.m. = 20° C. (14 readings).
Maximum, 29°·4 C., 8 a.m., 21st (Qa'a plain).
Minimum, 14°·4 C., 6 a.m.; 30th (in mountains).

Noon, 12 to 2 p.m. = 28°·8 C. (8 readings).
Maximum, 36°9 C., noon, 21st.
Minimum, 23°3 C., 11.25 a.m., 28th (Summit of Humr).

Evening, 5 to 7 p.m. = 24°·9 C. (10 readings).
Maximum, 36°·6 C., 5 p.m. (Qa'a plain).
Minimum, 16°·7 C. (Head of Wadi Tarfa).

From the above data it is evident that the open plain had great effect in increasing the average temperature.

* All temperatures given in this chapter are Centigrade.

Observations for November, 1898.

Date		Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898						
Nov.	1	6.50 a.m.	15	633·4	Head of Wadi Tarfa	Wind and Showers.
„	„	noon	14·4	633·9	do.	Showers.
„	„	5.25 p.m.	10·6	634·6	do.	Raining.
„	2	6.40 a.m.	11·5	633·7	do.	Fine, still morning.
„	„	1.45 p.m.	21·8	632·6	Head of Wadi Wa'era	Fine, fleecy clouds.
„	„	5.20 p.m.	16·8	632·6	do.	....
„	3	6.30 a.m.	11·5	631·9	do.	Still, chilly.
„	„	11.30 a.m.	17	585	Summit of Abu Mesud	....
„	„	2.— p.m.	18·2	583	do.	....
„	„	5.5 p.m.	19	652·4	Gorge of Wadi Nasb	....
„	4	5.30 p.m.	15·3	645	do.	Thunderstorms, showery or clouded.
„	5	6.25 a.m.	11·3	651·3	do.	Fine day, still, sunny.
„	„	1.55 p.m.	18·6	609	Summit of Gebel Beidha	....
„	„	6.— p.m.	18·5	652·0	Gorge of Wadi Nasb (mouth)	....
„	6	6.10 a.m.	9·1	651·7	do.	Still, fine.
„	7	4.30 p.m.	10·1	659·7	Near Nasb gorge	Fine, still, some fleecy clouds.
„	8	5.45 p.m.	19·5	672·8	Junction Wadis Um Rachal and Nasb	Fine, still.
„	9	6.30 a.m.	10·5	672·1	do.	At 11 a.m. hot, still.
„	„	5.— p.m.	19	670·8	do.	Some clouds.
„	10	6.25 a.m.	11	670·8	do.	Fine, still.
„	11	7.30 p.m.	13·4	670·7	do.	Fine, still, hot.
„	„	morning	10·5	670·5	do.	Towards 11 a.m. clouding up.
„	„	noon	19·5	669·3	Mouth of Wadi Um Beda	....
„	„	3.45 p.m.	17·7	...	Summit of Um Beda	Sky heavily clouded, no wind.
„	„	6.5 p.m.	14·4	667·1	Mouth of Wadi Um Beda	Chilly.
„	12	6.20 a.m.	9·3	666·5	do.	....
„	„	9.20 a.m.	17·5	667·8	do.	....
„	„	2.50 p.m.	18·2	665·9	do.	Slight showers.
„	„	9.25 p.m.	11·2	666·2	do.	Intensely still night.
„	13	7.— a.m.	12·5	666·4	do.	Clouded up towards afternoon, black clouds, showers, rain.
„	„	7.— p.m.	12·5	667	do.	Chilly.
„	14	7.45 a.m.	13	666	do.	Some clouds, chilly.
„	„	7.— p.m.	11·3	658·5	Head of Wadi Um Rachal	Windy, chilly.
„	15	7.— a.m.	7	658·9	do.	Small clouds.
„	„	3.— p.m.	13·9	...	Summit of Gebel Thaalbi	Chilly, little wind.
„	16	7.— a.m.	9·2	657·6	Head of Wadi Um Rachal	Air, still, clear.
„	„	1.— p.m.	11·8	626	Summit of Gebel Adakkar	....
„	„	4.10 p.m.	11·9	657	Head of Wadi Um Rachal	Windy, chilly.
„	„	7.— p.m.	9·6	657·9	do.	Air still.
„	17	6.— a.m.	5.5	657.5	do.	No wind, air still.

Observations for November, 1898 (continued).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Nov. 17	8.30 a.m.	9·7	657·9	Head of Wadi Um Rachal	Fine.
„ „	1.30 p.m.	11·9	...	Summit of Gebel Ashara	Fine, warm, no wind
„ „	5.50 p.m.	12·0	658·2	Head of Wadi Um Rachal	A few motionless fleecy clouds.
„ „	8.— p.m.	8·7	659	do.	
„ 18	6.— a.m.	6·1	659·8	do.	No wind, clear.
„ „	8.— a.m.	8·7	659·8	do.	....
„ „	4.15 p.m.	16·9	694·6	North bend of Wadi Nasb, 500 metres lower than previous camp.	Air still, clear.
„ „	8.— p.m.	14·1	695·4	do.	Still, clear, fine.
„ 19	5.40 a.m.	10·5	695·9	do.	Still, fine.
„ „	8.10 a.m.	13·6	695·8	do.	Windy, north.
„ „	2.40 p.m.	11·3	...	Summit of Gebel Ma'in	Keen north wind.
„ „	7.— p.m.	15·3	695·6	North bend of Nasb	do.
„ „	9.— p.m.	13	695·9	do.	Still.
„ 20	7.— a.m.	11·6	695·5	do	Air still, fine.
„ „	5.30 p.m.	16·8	692·1	do.	North wind.
„ „	7.— p.m.	16·5	693·1	do.	Air still.
„ 21	6.— a.m.	12·8	692·5	do.	North wind.
„ „	8.19 a.m.	14·4	692·9	do.	Heavy clouds from north.
„ „	10.30 a.m.	18·9	693·5	do.	Slowly moving clouds, occasional drops of rain.
„ „	6.— p.m.	15	687·7	Wadi Rahab	Still, fine.
„ 22	6.30 a.m.	8·8	689·7	do.	Quite still.
„ „	9.— a.m.	17	690·9	do.	Fine, still.
„ „	4.— p.m.	19·3	690·6	do.	Fine, sunny.
„ 23	6.15 a.m.	13·2	690·6	do.	Fine, still.
„ „	1.— p.m.	26·5	691·3	do.	Fine.
„ „	2.20 p.m.	25·5	690·9	do.	Rather hot.
„ „	4.30 p.m.	21·8	691·2	do.	Fine, still. Magnificent weather all day.
„ „	4.50 p.m.	21·0	...	do.	do.
„ „	7.40 p.m.	17·7	691·4	do.	Still night.
„ 24	6.10 a.m.	15	686·4	Wadi Rahab	Still.
„ „	11.15 a.m.	27	...	Station in Wadi Rahab	Faint breeze.
„ „	1.45 p.m.	28	...	do.	Fine.
„ „	3.30 p.m.	23·2	...	....	....
„ „	5.15 p.m.	21·3	697·3	South end Wadi Rahab	Still, cloudless.
„ „	8.35 p.m.	17·8	697·4	do.	Air still.
„ 25	6.15 a.m.	15·3	696·7	do.	Still, fine.
„ „	1.30 p.m.	22·4	...	Summit Gebel Zaimer	Hot, still, a whitish mist has risen over lower mountains.
„ „	7.30 p.m.	19·2	696·8	South end Wadi Rahab	....
„ 26	6.35 a.m.	14·4	696·1	do.	Still, fine.

Observations for November, 1898 *(continued)*.

Date	Time	Temperature Centigrade	Pressure Millimetre	LOCALITY	REMARKS
1898					
Nov. 26	9.— a.m.	22·9	...	South end Wadi Rahab	Hot, still.
" "	1.25 p.m.	26·5	712·8	Wadi Ethmoi and Wadi Kyd	Slight wind.
" "	3.25 p.m.	27	...	do.	Brilliantly fine, little windy.
" "	?.6 p.m.	24·4	712·4	do.	....
" "	8.— p.m.	22·2	712·5	do.	....
" 27	6.45 a.m.	17	712·9	do.	Still, windy night.
" "	2.10 p.m.	23	...	Gebel Ethmoi	Hot, still. In eveneng quite still, close.
" 28,29	..	..	...	Wadi Ethmoi and Wadi Kyd	Fine, hot, still days.
" 30,31	..	..	...	....	Fine, hot, still.

The month of *November* divides itself into two parts, the first half and especially the first week being very unsettled. Thus on the 1st a heavy thunderstorm broke over Wadi Tarfa, while on the 3rd and 4th there were thunderstorms in all directions, on the 3rd camp having to be moved to sloping ground, as a flood was expected. The second week was showery and chilly, but without electrical disturbances, and after the 21st the weather was continuously fine. The storms noted appeared to be coming from the south-west and were similar to the one recorded in October.

On the whole the month may be termed fine, the proportion of chilly, damp days to hot, fine ones, being: Chilly, etc., days 12. Fine, hot days 18.

The averages for the principal hours are:

Morning, 5 to 8 a.m. = 11°·3 C. (25 readings).

(This average would have been higher had the last three days been included, but owing to the illness of the observer, these observations were omitted.)

Maximum, 17° C., 6.45 a.m., 27th (in Wadi Kyd).
Minimum, 5°·5 C., 6 a.m., 17th (on plateau at head of Wadi Um Rachal).

Noon, or Maximum day Observations, *12 to 2* approximately = 19° C. (19 readings).

Maximum, 27° C., 3.25 p.m. (Wadi Kyd) on 26th.
Minimum, 11°·8, C. 1.0 p.m., 16th (summit of Gebel Adakkar).

Evening, 5 to 7 p.m. generally = 16°·2 C. (23 readings).

Maximum, 24°·4 C. on evening 27th (Wadi Kyd).
Minimum, 9°·6 C., 7 p.m., 16th (head of Wadi Um Rachal).

From this it will be seen that the coldest days were the 16th and 17th, the hottest the last four days of the month. There is one point of abrupt change to be noted which is directly correlated with a geographical change.

On the 18th the party was on the Sinai plateau, the morning temperature being 6°·1 C. only. In the evening the camp was in the deep rift of Wadi Nasb, and this descent was accompanied by sharp rise of temperature, 16°·9 C. being recorded in the evening, and 10°·5 C. the next morning.

The temperature-difference due to this change will be best shown by reference to the differences between the 17th and 19th.

	6 a.m.	8.30 a.m.	8 p.m.
17th (Plateau)	5.5	9.7	8.7
19th (Rift)	10.5	13.6	14.1
Difference	5.0	3.9	5.4

On the ascent of Gebel Ma'in, 600 metres above the valley, only 11·3 was recorded at 2.40 p.m., and keen wind was blowing, though the general conditions had not changed.

It may therefore be stated, as a first approximation, that the *temperature-difference between the Sinai plateau and the country south of the Transverse Divide* mentioned in the General Report *may be taken as from 4 to 5° C.*

Observations for December, 1898.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Dec. 2	7.30 a.m.	16·3	714	Wadi Ethmoi and Wadi Kyd	Cloudless.
„ „	11.10 a.m.	27·6	714·6	do.	Fine, hot.
„ „	1.10 p.m.	27	714	do	Still, hot.
„ „	4.15 p.m.	23·7	713	do.	Still, hot.
„ „	10.45 p.m.	15·4	712·9	do.	....
„ 3	6.30 a.m.	12·8	712	do.	Hot, fine, small clouds, but still.
„ 4	7.— a.m.	11·3	706·9	Higher up Wadi Kyd	Fine, clear, still.
„ 5	Early	8·9	707	do.	Still, fine.
„ „	9.— a.m.	20·3	708·9	do.	Still, hot.
„ „	5.30 p.m.	17·5	683·9	Wadi Humr	Fine.
„ „	8.— p.m.	15	684·3	do.	do.
„ 6	6.30 a.m.	8·9	682·7	do.	Fine, still day.
„ „	7.45 p.m.	15·4	683	do.	....
„ 7	6.50 a.m.	7·9	682·5	do.	Fine, still day.
„ „	8.— a.m.	13	682·6	do.	....
„ „	7.10 p.m.	16	682·4	do.	....
„ „	8.30 p.m.	13·8	682·7	do.	....
„ 8	Morning	8	683·9	do.	Clear, still.
„ „	7.10 p.m.	10·5	684·4	do.	Clear, still.
„ 9	7.— a.m.	7·8	685·2	do.	Still, fine.
„ „	9.— a.m.	16·3	685·8	do.	....
„ „	11.30 a.m.	23	..	do.	Air still, few clouds in western sky.
„ „	3.— p.m.	19·2	..	do.	....

Observations for December, 1898 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Dec. 9	5.30 p.m	15·8	675·4	Head of Wadi Humr	....
„ „	8.0 p.m.	15	675·4	do.	Still, a little cloudy.
„ 10	6.45 a.m.	12·5	674·4	do.	Still, a little cloudy.
„ „	3.50 p.m.	11·3	..	Summit of Gebel Mazea	Cloudy, breeze.
„ „	7.50 p.m	14·4	674·6	Head of Wadi Humr	....
„ 11	7.30 p.m.	11·1	687·1	Wadi Ethmid	Still, clear.
„ 12	7.— a.m.	11	665·4	do.	Little windy, masses of clouds all day.
„ „	7.— p.m.	13·3	663·9	do.	do.
„ 13	7.15 a.m.	9·4	663	do.	Slight breeze and considerable cloud. Evening clear again.
„ „	9.45 a.m.	13·8	663·6	do.	....
„ „	9.— p.m.	16·3	712·5	Wadi El Tema	....
„ 14	6.45 a.m.	10·8	712	do.	Still, clear, then cloudy and breeze to clear.
„ „	7.5 p.m.	14·4	713·1	do.	....
„ 15	7.— a.m.	5·7	713·6	do.	Clear, then white clouds.
„ „	6.30 p.m.	13	715·8	do.	Still, clear.
„ 16	7.40 a.m.	8·6	716·6	do.	White, clouds all day, no wind, hot sun.
„ „	12.40 p.m.	22·5	716·9	do.	do.
„ „	3.— p.m.	20·6	716·9	do.	....
„ „	5.50 p.m.	15·8	717·2	do.	....
„ „	8.— p.m.	12·4	717·2	do.	....
„ 17	6.50 a.m.	7·8	717·3	do.	Clear, still. Light puffs of wind to clear, still.
„ „	7.— p.m.	15·3	731·8	Wadi Gebila and Wadi Kyd	....
„ 18	6.45 a.m.	12·8	730·4	do.	Still, cloudy.
„ „	8.20 a.m.	16·1	730·4	do.	Still, clearing, then breeze, hot, misty.
„ „	5.30 p.m.	18	729·9	do.	Still, clear.
„ „	Night	13·8	730·2	do.	Still, clear.
„ 19	6.30 a.m.	8·7	729·2	do.	Clear, still, chilly.
„ „	8.30 a.m.	15·2	729·9	do.	Hot, still.
„ „	6.40 p.m.	19·8	739·2	Mouth of Wadi Gebila	Still, thin misty clouds
„ „	9.— p.m.	18·1	739·2	do.	do.
„ 20	7.— a.m.	19·2	738·2	do.	Still, cloudy.
„ „	8.— a.m.	19·8	738·2	do.	Still, cloudy. In afternoon at 3.15 breeze and cloudy.
„ „	6.15 p.m.	21	736·5	do.	Cloudy, still.
„ „	9.15 p.m.	19·2	736·8	do.	Warm and cloudy.
„ 21	6.40 a.m.	16·8	736·1	do.	Nearly clear.
„ „	9.— a.m.	20·6	738·3	do.	Breeze, few clouds.

Observations for December, 1898 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Dec. 21	12.45 p.m.	22·6	750·2	Sea-level, Ras Atantur	Fresh breeze, clouds.
„ „	7.— p.m.	17·8	745·5	Mouth of Wadi Kyd	Quite still.
„ „	9.30 p.m.	16·7	746·8	do.	Quite still.
„ 22	7.— a.m.	13	748·2	do.	Clear, chilly.
„ „	9.— a.m.	18·8	749·0	do.	At 4 pm. breeze, clouds
„ „	Evening	16·5	749·7	do.	Still, clear.
„ „	Evening	13·9	750·1	do.	Still, clear.
„ 23	6.30 a.m.	12	750·1	do.	....
„ „	9. – a.m.	17·9	751·4	do.	Clear, light breeze.
„ „	7.— pm..	15·3	740	Junction Wadi Kyd and Wadi Beda	Hot, still to slight breeze.
„ „	?.9 p.m.	13·7	740	do.	Clear, still.
„ 24	6.50 a.m.	12·8	737·7	do.	Clear, still.
„ „	8.35 a.m.	16·7	738·3	do.	Quite clear, still.
„ „	6.40 p.m.	14·4	735·2	do.	....
„ „	8.10 p.m.	17·3	735·5	do.	....
„ 25	7.30 a.m.	13	736·2	do.	Still and fine.
„ „	4.20 p.m.	15	726·2	Mouth of Wadi Zerig Yahamed	Brilliantly fine, still.
„ „	6.40 p.m.	12·8	726·2	do.	Colder, fine.
„ „	9.30 p.m.	10·8	726·6	do.	Quite still, clear moonlight.
„ 26	6.45 a.m.	8·0	726·5	do.	Air still, chilly.
„ „	8.40 a.m.	10·5	727·7	do.	Fine.
„ „	6.— p.m	12·8	728·4	do.	Air still, chilly.
„ „	9.30 p.m.	10·0	729·6	do.	Small fleecy clouds.
„ 27	6.20 a.m.	6·4	730·8	do.	Air still.
„ „	8.15 a.m.	8·3	732·2	do.	Fine, air still.
„ „	6.— p.m.	9·5	711·9	Centre of Wadi Yahamed	Air still, fine.
„ „	10.30 p.m.	8·0	712·3	do.	Air still.
„ 28	7.— a.m.	3·0	712·9	do.	Still, chilly, fine
„ „	6.25 p.m.	8·2	711·6	do.	Still, few fleecy clouds
„ „	10.— p m.	8·6	710·9	do.	Still.
„ 29	7.— a.m.	6·0	709·7	do.	Sky clear, still.
„ „	12.— p.m.	8·9	..	Summit of Um Ekhlis (nearly 1000 metres above valley)	....
„ „	3.— p.m.	10·2	..	do.	....
„ „	7.15 p.m.	8·0	708·7	Centre of Wadi Yahamed	Fine, still.
„ 30	7.— a.m.	2·9	708·3	do.	....
„ „	10.— a.m.	14·2	710·3	do.	Air still, fine.
„ „	12.— p.m.	17·0	..	Gorge of Wadi Yahamed	....
„ „	3.— p.m.	12·5	..	do. (higher)	Clouds drifting up from west.
„ „	5.30 p.m.	7·8	675	Foot of Gebel Sabbagh	....
„ 31	6.— a.m.	2·5	674·6	do.	Still fine, a few clouds
„ „	2.10 p.m.	5·3	..	Summit of Gebel Sabbagh	....

The lowest recorded temperature for the month of *December* was noted on the *31st* at *6 a.m.* at the foot of Gebel Sabbagh (Central Range) = $2^{\circ}.5$ C., the *highest* on the 2nd (no record for the 1st) in Wadi Kyd, viz., *27°.6* at *11.10 a.m.*

The Morning Average 6 to 8 a.m. = $9^{\circ}.8$ C. (29 readings), the *Maximum* being $19^{\circ}.2$ C. at 7 a.m. on the 20th (month of Wadi Gebila). *Minimum* $2^{\circ}.5$ C. at 6 a.m. Gebel Sabbagh.

Too few *Midday* temperatures were taken to form an average; such as were noted vary from $5^{\circ}.3$ C. on the summit of Sabbagh (at 2.10 p.m. on the 31st), and $10^{\circ}.2$ C. on summit of Um Ekhlis (on the 29th at 3 p.m.), to $22^{\circ}.6$ C. at sea-level, Gulf of Akaba, (at 12.45 p.m. of the 21st), and 27° C. (at 1.10 p.m. of the 2nd) in Wadi Kyd.

Evening temperatures (6 to 8 p.m.) (27 readings). Most of the readings were taken about 7 p.m., the time of return to camp.

Average = $14^{\circ}.3$ C. *Maximum* 21° C. on the 20th, at 6.15 p.m. (mouth of Wadi Gebila). *Minimum* $7^{\circ}.8$ C. on the 30th, at foot of Gebel Sabbagh.

Although no midday averages were taken, the regularity of difference for the preceding months may enable us to suggest a probable figure.

Average	Half October	November	December
Morning......................	20	11.3	9.8
Afternoon....................	28 8	19	17.3
Evening......................	24.9	16.2	14.3

Wind. A remarkable feature of this month was its freedom from wind Only on 10 out of the 31 days have breezes been recorded, and these always light and in the afternoon, with one exception, the night of the 24th.

Cloud. These were noted on 17 days, but usually small and fleecy. *Cirrus.* Only on the 12th, 13th and 16th were these in mass. There was lightning to the north on the 11th.

Snow. On the night of the 27th a heavy cloud came up over Gebel Sabbagh, the neighbouring summits remaining clear. When it lifted next morning the mountain was covered with snow, which was still lying thick on the slopes when we ascended it on the 31st, the result being that two of the Arabs were frost-bitten, and one developed night-blindness.

Observations for January, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Jan. 3	2.20 p.m.	6.2	..	Summit of Um Adowi	Previous days fine, still, few clouds, light breeze.
„ 4	3.20 p.m.	10·3	..	Summit of Gebel Barakat	Still, clear, warm.
„ „	Evening	6·9	707·5	Foot of Um Adowi	....
„ 5	7.— a.m.	5·9	704·7	do.	Still, fine.
„ „	9.15 a.m.	12·7	706·4	do.	Still, clear.
„ 6	3.15 p.m.	14·0	..	Summit of Gebel Battach	Misty.
„ „	8.30 p.m.	7·0	729·1	Centre of Um Adowi	Clear, still.
„ 7	7.— a.m.	5·4	727·7	do.	....
„ 8	6.— p.m.	11·9	737·9	Lower part of Um Adowi	Gusts of wind.
„ „	8.20 p.m.	10·4	738·6	do.	Occasional gusts of wind.
„ 9	6.30 a.m.	2·0	741·2	do.	Still, clear.
„ „	8.10 a.m.	6·0	741·9	do.	Snow on Jebel Zebir.
„ „	5.45 p.m.	10·6	742·7	do.	Still, clear.
„ „	9.30 p.m.	6·4	743·7	do.	Still, clear, fine. Frost at night.
„ 10	6.35 a.m.	3·3	745·2	do.	Still, clear.
„ „	8.30 a.m.	5·6	745·7	do.	Clear, still.
„ „	6.— p.m.	12·2	759·2	Nebk (sea-level)	Little cloudy.
„ „	7.10 p.m.	12·9	759·7	do.	Breeze, cloudy.
„ „	9.— p.m.	12·4	759·8	do.	Land breeze.
„ 11	8.40 a.m.	15·4	758·7	do.	Windy, cloudy, about 4 o'clock still.
„ 12	8.— p.m.	9·0	747	Foot of Gebel Giada	Zodiacal light, clear, still.
„ „	9.50 p.m.	13·0	746·9	do.	Still, clear
„ 13	7.45 a.m.	13·4	748	do.	Windy cloudy.
„ „	9.— a.m	16·0	748·2	do.	Thin clouds, fresh breeze all day, still at night.
„ „	9.30 p.m.	10·3	755·2	Aad Bay	....
„ 14	8.— a.m.	14	754·4	do.	Clear, still, light breeze, few clouds at noon.
„ „	9.40 p.m.	14·9	754·7	Sherm	Zodiacal light and windy. Windy night.
„ 15	8.— a.m.	13·7	754·9	do.	Still, but breeze about noon. Rain in night and early.
„ 16	Morning	17·4	753·2	do.	Cloudy, breeze.
„ „	12.— p.m.	19·2	751·4	do.	Clearing.
„ „	2.15 p.m.	18·4	751·1	do.	Strong wind.
„ „	4.30 p.m.	16·3	750·8	do.	....
„ „	6.— p.m.	15·4	750·7	do.	Blowing hard.

Observations for January, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Jan. 17	9.30 a.m	11·3	752·4	Sherm	Blowing hard. Wind moderated about 4 p.m.
„ „	7.— p.m.	10·4	752·4	Hedemia Bay	Still, some clouds.
„ „	9.— p.m.	10·4	752·7	do.	Cloudy, chilly. Wind in night.
„ 18	7.15 a.m.	10·6	755·7	do.	Still.
„ „	9.— a.m.	14·4	757·2	do.	Still, fine.
„ „	10.45 a.m.	17·8	..	Low hills * west of St. 8	West breeze, clear.
„ „	2.— p.m.	17·3	..	do. (Sheet 11) St. 9	Breeze.
„ „	5.— p.m.	14·4	..	do. St. 10	Still, clear.
„ „	6.45 p.m.	10·4	757·5	Hedemia Bay	Clear, no clouds.
„ „	8.— p.m.	9·2	756·7	do.	Still, clear.
„ 19	7.— a.m.	8·2	759·3	do.	....
„ „	8.35 a.m.	14·4	759·1	do.	....
„ „	11.30 a.m.	18·3	..	Sheet 11 { Low hills S. of St. 11	S.W. breeze.
„ „	3.30 p.m.	17·8	..	do. 12	Windy.
„ „	5.30 p.m.	15	..	do. 13	W. breeze.
„ 19	9.10 p.m.	10	757·7	Ras Mohammed	Clear, still.
„ 20	7.10 a.m.	8·3	757·8	do.	Clear, still.
„ „	9.— a.m.	12·8	759·7	do.	....
„ „	11.15 a.m.	17·5	..	Sheet 11, St. XIV.	Light breeze, east.
„ „	12.20 p.m.	20	..	do. XV.	N.E. breeze.
„ „	1.50 p.m	17·8	..	do. XVI.	Breeze light.
„ „	3.15 p.m.	18·3	..	do. XVII.	....
„ „	4.35 p.m.	16·7	..	do. XVIII.	Westerly breeze, light, fine.
„ „	Evening	14·4	..	do. XIX.	....
„ „	10.30 p.m.	10·9	758·2	Ras Mohammed	Still.
„ 21	7.40 a.m.	12·7	758·3	do.	Still, clear.
„ „	9.— a.m.	14·4	759·3	do.	Still, clear.
„ „	11.— a.m.	17·8	..	Sheet 11, St. XX.	S.E. breeze, wind changing.
„ „	2.— p.m.	17·8	..	do. XXII.	W. breeze.
„ „	4.35 p.m.	15	..	do. XXIII.	W. breeze.
„ „	Evening	11·7	744·4	Wadi Hashubi	Still, clear.
„ 22	7.10 a.m.	8·9	740·4	do.	....
„ „	8.10 a.m.	14·9	741·2	do.	....
„ „	1.30 p.m.	17·9	..	Sheet 11, St. XXV.	West wind, some cloud.
„ „	6.— p.m.	14·4	738·6	Wadi Hashubi	Still.
„ 23	7.15 a.m.	7·0	739	do.	Still, clear.
„ „	8.20 a.m.	11·7	740·2	do.	do.
„ „	12.20 p.m.	19	..	Sheet 11, St. XXVII.	do.
„ „	2.30 p.m.	21	..	do. XXVIII.	Clear, W. breeze.
„ „	5.15 p.m.	16·1	..	do. XXIX.	West breeze.
„ „	9.30 p.m.	10·0	735·5	Wadi Madsus	Clear, still.

* These stations are on low hills between Sherm and Ras Mohammed and are shown on the field-sheets kept in the Survey Department.

Observations for January, 1899 *(continued)*.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Jan. 24	7.10 a.m.	6·7	735·7	Wadi Madsus	....
" "	8.45 a.m.	12·2	756·4	do.	....
" "	12.40 p.m.	15·4	..	Summit Gebel Hedemia (300 metres above valley).	Still, clear.
" "	8.30 p.m.	10·6	736·1	Wadi Madsus.	do.
" 25	6.45 a.m.	6·7	735·3	do.	do.
" "	8.30 a.m.	11·1	736·4	do.	do.
" "	12.10 p.m.	15	..	Gebel Wa'ar (about 200 metres above camp).	Clear, slight breeze.
" "	8.35 p.m.	9·6	..	Wadi Madsus.	....
" "	10.— p.m.	9·4	736·4	do.	Still, clear.
" 26	7.— a.m.	13·3	736·2	do.	do.
" "	9.50 a.m.	16·7	737·6	do.	West breeze.
" "	3.30 p.m.	16·1	..	Gebel Um Markha	do.
" "	6.— p.m.	15·0	..	Head of Wadi Awaja.	Still, clear.
" "	8.45 p.m.	10·6	720·4	do.	do.
" 27	6.— p.m.	14·4	721·8	do.	Still, a few clouds.
" "	8.20 p.m.	12·8	722·3	do.	Still, clear.
" 28	7.— a.m.	10·8	722·4	do.	do.
" "	8.25 a.m.	13·8	723·2	do.	Still.
" "	12.30 p.m.	19·7	740·1	Gebel Nimr (low hill)	Still, hot.
" "	4.45 p.m.	17·1	..	Gebel Dajilat.	Few clouds.
" "	7.45 p.m.	14·2	737·6	Wadi Aad.	....
" "	Later	13·8	738	do.	Clear, still.
" 29	8.15 a.m.	14·4	737·2	do.	Still, clear.
" "	1.10 p.m.	19·7	..	Sheet 11, St. XXXIX.	Still, brilliantly fine, no clouds.
" "	9.— p.m.	15	735·8	Wadi Aad.	Still, few clouds.
" 30	10.20 a.m.	20	736·1	do.	Still, clear.
" "	4.10 p.m.	17·2	..	Sheet 11, St. XLII (about 500 metres above camp)	do.
" "	6.45 p.m.	17·2	735·6	Wadi Aad.	do.
" "	8.30 p.m.	12·8	735·7	do.	....
" 31	8.35 a.m.	15·9	737·3	do.	Still, fine.
" "	11.— a.m.	20	738·2	do.	Still, some clouds.
" "	3.— p.m.	23·3	737·1	do.	Still, clear.
" "	6.— a.m.	17·2	737·8	do.	Still.

The *Maximum* noted for January was 23°·3 C. at 3 p.m., on the 31st in Wadi Aad. *Minimum*, 2° C. at 6.30 a.m. on the 9th in Wadi Um Adowi, on which day there was frost at night, and Zebir was covered with snow.

Morning average (mainly 6 to 8 a.m.) = 10° C. (21 readings).

Maximum, 16°·9 C. at 8.35 a.m. on 31st in Wadi Aad.

Minimum, 2° C. at 6.30 a.m. on 9th in Wadi Um Adowi.

Afternoon averages=17°·3 C. (17 readings) the *Maximum* noted being 23°·3 C. at 3 p.m. on 31st in Wadi Aad, the *Minimum* 6°·2 C. at 2.20 p.m. on the 3rd, on summit of Um Adowi.

Evening averages = 12°·8 C. (24 readings), the *Maximum* record being 17°·2 C. at 6.45 p.m. on the 30th, and again at 6 p.m. on the 31st, both in Wadi Aad, the *Minimum* 6°·9 C. on evening of the 4th, foot of Um Adowi.

Practically, the cold period began about the 25th of December, 1898, and was more or less marked till the 26th of January. From the 30th December to the 10th January there was no record over 14° C.

The wind observations were exceptionally numerous in January owing to our lengthened stay near the Gulf of Akaba. *Wind* was noted on 17 days, blowing exceptionally hard at Sherm from 16th to 18th, with rain on the night of the 15th. *Cloud* was noted on 13 days, but mostly only of the small fleecy type. Often when on the central summits it was perfectly still and clear, the waters of the Gulf of Akaba were seen to be foam-tipped, indicating the action of strong winds.

Observations for February, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Feb. 1	3.— p.m.	20·6	..	Sheet 12. St. II*	Misty, cloudy.
” ”	5.— p.m.	20·6	..	” St. III	Cloudy.
” 2	7.40 a.m.	15·6	736	Wadi Aad	Still, clear.
” ”	8.35 a.m.	17·8	..	do.	do.
” ”	11.45 a.m.	21·7	..	Sheet 12. St. IV	do.
” ”	5.— p.m.	18·9	..	” St. V	do.
” 3	7.15 a.m.	13·3	714·7	Head of Wadi Aad	do.
” ”	8.15 a.m.	15·2	..	do.	do.
” ”	Noon	15·6	..	Summit of Haimar (nearly 1000 metres above camp)	Cloudy, hot, still.
” ”	Evening	16·5	714·2	Head of Wadi Aad	Still, clear.
” ”	Later	16·7	714·7	do.	do.
” 4	7.15 a.m.	15	712·6	do.	do.
” ”	?8.15 a.m.	18·3	..	do.	do.
” ”	Noon	18	..	Summit of Aad (about 900 metres rise) †	....
” ”	7.15 p.m.	16·4	710·1	Head of Wadi Aad	Big wind in night.
” 5	7.45 a.m.	15	710·3	do.	Misty, still.
” ”	1.30 p.m.	13·2	..	Summit of Aad El Gharbi (about 600 metres)†	Strong west wind.
” ”	7.10 p.m.	15·4	710·7	Head of Wadi Aad	At 3.30 S.W. wind, hazy, then at 7 clear sky, gusts of wind.
” 6	7.30 a.m.	11·7	711·3	do.	Still, hazy.
” ”	8.15 a.m.	13·3	711·7	do.	Windy, west wind, white clouds in day, evening still.
” 7	2.— p.m.	17·9	..	Gebel Khurum	West wind, cloudy.
” ”	7.— p.m.	14·8	733·1	Wadi Mnidri	Still.

* Low stations in or near Wadi Aa'd.
† Heights above camp.

Observations for February, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Feb. 7	8.45 p.m.	14·8	733	Wadi Mnidri.	Still, clear.
„ 8	1.30 p.m.	17·8	..	Summit of Mabledge (300 metres)*	Light breeze.
„ 9	12.30 p.m	20·6	720·8	Wadi Letih	Clear, hot.
„ „	6.30 p.m.	16·3	718·2	do.	Still, clear.
„ 10	8.30 a.m.	15	716·7	do.	do.
„ „	12.— p.m.	17·8	717·4	do.	Clouding.
„ „	6.— p.m.	13·8	717·2	do.	Raining.
„ 11	7.20 a.m.	11·1	717·9	do.	Clear, still.
„ „	12.45 p.m.	9·2	..	Summit of Mobera (600 metres)*	Showers, rain, heavy cloud. At 2.45 N.W. clouds.
„ „	9.30 p.m.	11·7	719·4	Wadi Letih	Clear, still.
„ 12	7.— a m.	9·4	719·3	do.	do.
„ „	10.30 a.m.	15	..	Sheet 12. St. XVI. Higher up Wadi Letih	Clear, fine.
„ „	2.30 p.m.	15·2	..	do.	West breeze, clouds.
„ „	3.30 p.m.	15	..	do.	White clouds.
„ „	4.15 p.m.	13·3	..	do.	West breeze.
„ „	5.20 p.m.	12·4	694·8	Head of Wadi Letih	Still, clear.
„ 13	7.15 a.m.	9·2	693·9	do.	do.
„ „	8.10 a.m.	13	694·6	do.	do.
„ „	12.— p.m.	11·1	..	Gebel Letih (500 metres)*	East breeze, clouds.
„ „	7.40 p.m.	12·8	695·2	Head of Wadi Letih	Clear, still.
„ 14	7.15 a.m.	11·7	693·7	do.	do.
„ „	10.45 a.m.	14·2	..	Sheet XXXV (300 metres)*	Clear, breeze.
„ „	about 2 p.m.	15	..	Sheet XXXVI (500 metres)*	Clear, still.
„ 15	8.— a.m.	12·8	691·7	Head of Wadi Letih	do.
„ „	3.50 p.m.	12	..	Summit of Ethnarbi	Still, few clouds.
„ „	8.— p.m.	12·8	691·2	Head of Wadi Letih	Still, clear.
„ 16	..	..	..	....	....
„ 17	7.— p.m.	12·2	694·2	Wadi Um Zeinig	Still, clear.
„ „	9.30 p.m.	12·2	693·6	do.	do.
„ 18	7.20 a.m.	11·0	691·8	do.	Clear, still.
„ „	Afternoon	15·6	..	Summit Um Zeinig (400 m.)*	West breeze, clear.
„ „	7.— p.m.	15·6	691·9	Wadi Um Zeinig	Clear, still.
„ „	8.50 p.m.	14·4	691	do.	....
„ 19	1.— p.m.	20·0	690·6	do.	Clear, still.
„ „	6.30 p.m.	15·8	690·6	do.	Gusts of wind.
„ 20	7.10 a.m.	13·9	689·8	do.	Cloudy.
„ „	9.30 a.m.	17·5	690·4	do.	Clearing.
„ „	2.30 p.m.	17·8	689·7	do	Wind and cloud.
„ „	5.10 p.m.	16·7	689·1	do.	Gusts of wind.
„ „	8.— p.m.	13·9	689·2	do.	....
„ 21	8.30 a.m.	11.1	688·4	do.	Still, clear.
„ „	1.20 p.m.	11·7	..	Summit El Khor (400 metres)*	do.
„ „	3.— p.m.	13·2	..	Wadi Um Zeinig	West breeze.
„ „	5.10 p.m.	10·0	..	Sheet 12. St. XXXIII (low)	West wind .

* The heights shown are above valley level.

Observations for February, 1899 (*continued*).

Date	Time	Temperature centigrade	Pressure millimetres	LOCALITY	REMARKS
1899					
Feb. 21	7.30 p.m.	8·3	694·3	Wadi Mazea	Very misty, few clouds.
„ 22	7.30 a.m.	5·0	696·4	do.	Still, clear.
„ „	2.40 p.m	8·0	..	Sheet 12. St. XXXIV (700 metres) Gebel Sahara	Clear, very still.
„ „	4.45 p.m.	8·9	..	Sheet 12. St. XXXV (700 metres) Gebel Sahara	Still, little mist.
„ „	8.— p.m.	10·0	697·5	do.	....
„ „	9.40 p.m.	8·3	697·6	Wadi Mazea	Still, clear.
„ 23	7.— a.m.	5·0	696·7	do.	do.
„ „	8.30 a.m.	8·9	696·9	do.	do.
„ „	12.— p.m.	10·6	..	St. XXXVI. (600 metres)	Clear, still.
„ „	3.30 p.m.	12·8	..	do.	do.
„ „	7.— p.m.	15·2	696·7	Wadi Mazea	do.
„ 24	7.30 a.m.	8·3	696·4	do.	do.
„ „	8.30 a.m.	12·2	696·8	do.	do.
„ „	11.20 a.m.	13·1	..	Sh. 12. XXXIII. (300 metres)	do.
„ „	4.— p.m.	12·8	..	Gebel Ergain (400 metres)	East breeze.
„ „	8.— p.m.	15	717·8	Wadi Letih (same camp 9th to 12th)	Clear, still.
„ 25	7.15 a.m.	15	715·6	do.	do.
„ „	8.15 a.m.	17·8	715·7	do.	do.
„ „	1.30 p.m.	20·6	..	Sh. 12. St. XXXIX (300 m.)	East breeze.
„ „	5.30 p.m.	18·3	..	Sheet XL (low)	....
„ „	8.— p.m.	15	717·8	Wadi Letih	Still, clear.
„ 26	7.15 a.m.	13·3	714·2	do.	Still, fine.
„ „	8.25 a.m.	18·3	713·7	do.	....
„ „	12.— p.m.	24·4	..	St. XLI (200 metres)	South wind, hazy.
„ „	4.5 p.m.	21·1	..	St. XLII (200 metres)	West wind.
„ „	7.30 p.m.	19·4	714	Wadi Letih	....
„ 27	7.15 a.m.	15·2	715·2	do.	S.E. wind, clear.
„ „	8.30 a.m.	17·8	715·6	do.	Still, clear.
„ „	11.30 a.m.	21·1	..	Gebel Um Ebeirig (low)	Still, misty, haze and white clouds.
„ „	1.30 p.m.	21·4	..	Wadi Gafar da Falla	S.E. breeze.
„ „	4.45 p.m.	17·0	..	Gebel Beidha (nearly 300)	Misty, S.E. breeze.
„ „	7.— p.m.	16·4	725·3	Wadi Gafar da Falla	Air still.
„ „	8.30 p.m.	16·1	725·3	do.	Still, clear.
„ „	10.— p.m.	15·3	725·4	do.	do.
„ 28	7.30 a.m.	11·7	726·2	do.	do.
„ „	8.40 a.m.	15·0	726·4	do.	do.
„ „	11.— a.m.	17·8	..	Gebel Beidha El Asrar (low)	Clear, S.E. breeze.
„ „	12.30 p.m.	21·1	..	Wadi Um Bsilla	do.
„ „	4.20 p.m.	18·2	..	Gebel..... (200 metres)	East breeze.
„ „	5.45 p.m.	19·4	..	Wadi Naas	do.
„ „	7.— p.m.	17·0	728·6	do.	Still, clear, zodiacal light.

* Heights shown are above valley level. The numbers indicate low valley stations whose exact position is shown on the original field-sheets.

The *Maximum* noted for February was $24^{\circ}{\cdot}4$ *C.* at 12 p.m. on summit of station above Wadi Letih (26th), a south wind blowing. *Minimum,* 5° *C.* at 7.30 p.m. on 22nd, and at 7 a.m. on the 23rd in Wadi Mazea among the hills.

21 Morning Readings give an average of $11^{\circ}{\cdot}9$ C. the *Maximum* noted being $15^{\circ}{\cdot}6$ *C.* at 7.40 a.m. on the 2nd in Wadi Aad, the *Minimum,* 5° *C.* at 7 and 7.30 a.m. in Wadi Mazea (see above).

The comparatively low average for the afternoon temperatures (25 readings) = $16^{\circ}{\cdot}5$ C. is due to the faet that a large number of these were taken on mountain summits. The *Maximum* was $24^{\circ}{\cdot}4$ *C.* at 12 p.m. (for locality see above), and the *Minimum,* $8^{\circ}{\cdot}0$ *C.* at 2.40 p.m., on the summit of Gebel Sahara. (500 metres.)

24 Evening Temperatures gave an average of $14^{\circ}{\cdot}7$ C., the *Maximum* being $20^{\circ}{\cdot}6$ *C.* at 5 p.m. on the 1st (St. I, Sh. 12, see map). *Minimum,* $8^{\circ}{\cdot}9$ *C.* at 4.45 p.m. on summit of Gebel Sahara.

The country traversed may be divided into two regions, one a closed mountain district only entered by a narrow gorge at the head of Letih, and the other more open country; 13 days were spent in the former, 15 in the latter. The temperature rose ten times over 20° C. in the low country, and only fell once below 10° C. In the mountain district, on the contrary only once was 20° C. just reached, while ten times the temperature was 10° C. or under, so that the contrast due to geographical position is well marked, and unfortunately at the same time reduces the value of the averages.

Rain. A heavy rainstorm burst over the Hamar range on the 11th, in a few minutes torrents pouring in cascade and waterfall down the sides, dislodging huge fragments of rock. On the station opposite, Gebel Mobera, we escaped with only three falls of hail the storm area being sharply marked off about 100 metres from the summit. The storm ended as abruptly as it began, and at night the record was again clear and still. Rain was also noted on the 10th, mainly small showers.

Wind. The early part of the month was very windy, the night of the 4th being unpleasantly noticeable for its gusts, while on the afternoon of the 7th the tents were pitched as high up a small boulder valley as possible in order to escape their effect. This was probably the most windy month of any yet recorded, ten days of heavy wind being noted, and ten of light afternoon breezes. The first-named were mainly from the west or S.W., while the light breezes were chiefly east or S.E.

Cloud. During the first three weeks the afternoons were frequently misty or cloudy, but after the 21st, the days were generally clear, especially morning and evening and while the eastern breezes were blowing.

Observations for March, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
March 1	7.10 a.m.	12·8	729·4	Wadi Na'aj	Still, misty.
„ „	8.10 a.m.	16·1	729·8	do.	Still, clear.
„ „	2.25 p.m.	18·3	..	Summit Gebel Ajuaf (500 m.)	East breeze.
„ „	Evening	18·3	729·5	Wadi Na'aj	Still.
„ 2	7.30 a.m.	12·8	728·7	do.	Still, cloudy.
„ „	10.30 a.m.	18·9	729·6	do.	do.
„ „	12.50 p.m.	22·8	727·9	do.	Still, few clouds.
„ „	3.50 p.m.	23·3	726·7	do.	Still, hazy.
„ „	5.20 p.m.	22·2	726·3	do.	do.
„ „	9.— p.m.	16·1	726·7	do.	Still, clear.
„ 4	9.15 a.m.	19·5	728·7	Wadis Gebila and Kyd	do.
„ „	9.— p.m.	18·3	727·8	do.	Rain, Thunder and Thunder showers, unsettled.
„ 5	7.10 a.m.	16·1	727·7	do.	Clear, still.
„ „	3.50 p.m.	16·0	..	Gebel Madsus (700 metres)	Misty, white clouds.
„ „	8.30 p.m.	19·2	725·8	Mouth Wadi Madsus	Clear, still.
„ 6	7.— a.m.	12·8	725·5	do.	do.
„ „	8.15 a.m.	17·5	704·4	Head of Wadi Madsus	do.
„ 7	7.30 a.m.	13·3	705·2	do.	do.
„ „	10.15 a.m.	16·7	..	Station (500 metres)	....
„ „	1.— p.m.	20·0	..	do.	S.W. breeze.
„ „	4.— p.m.	15·8	..	do.	....
„ „	6.15 p.m.	18·3	705·1	Head of Wadi Madsus	Clear, still.
„ 8	1.30 p.m,	19·4	..	Station (400 metres)	West breeze.
„ „	4.15 p.m.	18·3	..	Another Station (400 metres)	Faint breeze, clear.
„ „	7.40 p.m.	18·9	704.2	Head of Wadi Madsus	Clear, still.
„ 9	7.12 a.m.	12·8	703·6	do.	do.
„ „	8.15 a.m.	16·7	704·5	....	....
„ „	12.30 p.m.	20·6	..	St. Gebel Hamra Er Rahab (600 metres)	Clouding, E. breeze.
„ „	3.30 p.m.	20	..	do.	Cloudy, still.
„ „	4.40 p.m.	17·2	..	Another Station (600 metres)	Some clouds.
„ „	8.25 p.m.	19·2	683·8	Head Wadi Sai'amin	Clear, still.
„ 10	7.30 a.m.	13·3	684·5	do.	do.
„ „	12.— p.m.	17·8	..	Gebel Um Aleg (700 metres)	Hazy, nearly clear, East breeze.
„ „	1.— p.m.	16·7	..	2nd Station do.	Hazy, still.
„ „	4.20 p.m.	14·4	..	3rd Station do.	do.
„ „	8.5 p.m.	17·8	687·3	Head Wadi Sai'amin	Still.
„ „	10.— p.m.	17·8	687·7	do.	Still, clear.
„ 11	7.10 a.m.	15·6	687·5	Head of Wadi Sai'amin	Still, clear.
„ „	12.30 p m.	20·6	..	Summit of Sowila (500)	Hazy, still.
„ „	2.45 p.m.	21·1	..	do.	do.
„ „	5.50 p.m.	20·6	687·9	Head of Wadi Lij	Clear, still.
„ 12	8.10 a.m.	17	688·7	do.	do.
„ „	12.30 p.m.	22	688·4	do.	Breeze.
„ „	3.30 p.m.	22·2	688·3	do.	Still, clear.

* Heights given above valley level.

Observations for March, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Mar. 13	6.50 a.m.	7·2	691·4	Head of Wadi Lij	Still, clear. Then N.E. breeze.
„ „	8.— a.m.	13·3	686·0	do.	Still, clear.
„ 14	7.— a.m.	11·3	687·8	do.	do.
„ „	9.— a.m.	18·3	686·4	do.	do.
„ „	11.— a.m.	20·0	688·3	do.	do.
„ „	1.— p.m.	21·1	688·4	do.	Breeze.
„ „	3.— p.m.	22·8	687·7	do.	....
„ „	5.— p.m.	20·8	686·8	do.	Still, cloudy.
„ „	7.— p.m	18·2	686·8	do.	do.
„ 16	7.— a.m.	18·3	710·4	Head of Wadi Madsus	Still, heavy, close.
„ „	8.30 a.m.	20·0	710·9	do.	Heavily clouded.
„ „	2.30 p.m.	21·1	..	Gebel Sailem (500 metres)	do.
„ „	6.— p,m.	25·5	705·2	Head of Wadi Madsus	Cloudy, still.
„ 17	7.— a.m.	20·6	704·4	do.	do.
„ „	8.30 a.m.	22·8	704·6	do.	do.
„ „	1.— p.m.	26	..	Gebel Ethmemia (300 m.)	do.
„ „	5.10 p.m.	21·7	..	Gebel Akhmara	Cloudy, misty.
„ „	8.15 p.m.	23·3	723·9	Mouth of Wadi Madsus	Still, misty. Rain in night.
„ 18	7.10 a.m.	23·8	723·5	do.	Cloudy, still.
„ „	8.30 a.m.	20·6	723·6	do.	do.
„ „	10.40 a.m.	22·8	..	Station (300 metres)	Heavily clouded, foggy.
„ „	2.45 p.m.	19·4	..	do. (200 metres)	Later raining.
„ 19	6.40 a.m.	18·3	699·5	Wadi Abu Esherat	Cloudy, still.
„ „	8.— a.m.	19·4	700·1	do.	Misty.
„ „	3.— p.m.	20·0	...	Gebel Abu Esherat (500 m.)	Cloudy, breezes.
„ „	8.— p.m.	20·3	700·6	Wadi Abu Esherat	Light puffs of wind, some clouds.
„ 20	1.30 p.m.	21·4	..	Two stations 150 to 250 metres above valley	Some clouds, little hazy.
„ „	5.— p.m.	20·0	..		Hazy, still.
„ 21	7.30 a.m.	15·6	702·8	Wadi Abu Esherat	Still, clear.
„ „	4.30 p.m.	21·1	..	Station (300 metres)	Hazy still.
„ „	?10.30 p.m.	17·2	713·9	Wadi Um Zeireh	Still, clear.
„ 22	7.30 a.m.	17·2	714·9	do.	do.
„ „	8.40 a.m.	23·3	715·8	do.	do.
„ „	10.30 a.m.	27·2	..	St. XVI } Stations 100 to 200 m. above valley	do.
„ „	12.— p,m.	23·9	..	St. XVII	North East breeze.
„ „	3.— p.m.	23·9	..	St. XVIII	Clear, North East breeze.
„ „	6.— p.m.	22·8	700·0	Wadi Gnai	Clear, still.
„ „	Later	21·0	700·3	do.	....
„ 23	6.30 a.m.	17·2	700·2	do.	Clear, still.
„ „	8.— a.m.	17·8	701·2	do.	do.
„ „	12.15 p.m.	21·7	..	St. XIX } Both 400 m. above valley	Clear, E. breeze.
„ „	3.15 p.m.	23·9	..	St. XX	do.

* Heights given above valley level.

Observations for March, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Mar. 23	7.— p.m.	23·3	708·5	Wadi Hamra	Little wind.
„ 24	7.— a.m.	15·6	707·6	do.	Still, clear.
„ „	8.— a.m.	20	708·1	do.	do.
„ „	9.40 a.m.	22·2	..	Stations both 500 m. above valley	Clear.
„ „	12.— a.m.	23·9	..		Still, clear.
„ „	7.30 a.m.	23·3	706·3	Wadi Hamra	do.

NOTE.—At this point the sling thermometer hitherto used was broken, and a smaller one, which had previously been compared with the standard one at Cairo, came into use.

„ 25	7.— a.m.	20·4	706·4	....	Still, clear.
„ „	10.30 a.m.	31·7	..	Hill Stations, 100 to 300 m. above valley	do.
„ „	12.30 p.m.	32·6	..		Few clouds, still,
„ „	Afternoon	31·7	..		Still, hazy.
„ „	10.— p.m.	25·3	706·4	Wadi Hamra	Still, clear.
„ 26	7.— a.m.	22·6	706·2	....	do.
„ „	10.— a.m.	35	..	....	Still, white cloudy.
„ „	1.10 p.m.	33·3	..	Station Gebel Beidha, 250 metres above valley	Squally, clouds.
„ „	2.30 p.m.	32·2	..		Clouds, E. wind.
„ „	6.— p.m.	30·8	713·5	Wadi Seyal Noma	Still, little clouds.
„ „	7.50 p.m.	27	713·5	do.	....
„ 27	8.— a.m.	27·2	712·8	do.	Cloudy, still. Heavily clouded during day.
„ „	7.— p.m.	27·7	710·8	do.	Still, drops of rain.
„ 28	7.20 a.m.	16·4	710·0	do.	High wind, N. clear. In afternoon wind went down.
„ „	9.— p.m.	17·2	730·3	Base Wadi Moghtut	Windy.
„ 29	6.45 a.m.	12·6	732·4	do.	do.
„ „	8.— a.m.	16	733·4	do.	Clear, breeze.
„ „	11.— a.m.	14·7	..	Stations 200 metres above valley	N.E. wind.
„ „	3.— p.m.	16·8	..		Clear, breeze.
„ „	8.— p.m.	17·4	751·4	Month of Wadi Gnai El Atshan	N. breeze, blowing at night.
„ 30	6.30 a.m.	14·4	752·4	do.	N.E. breeze.
„ „	12.30 p.m.	18·9	..	Stations 350 metres above valley	do.
„ „	2.— p.m.	18·9	..		do.
„ „	9.30 p.m.	17·6	752·8	....	do.
„ 31	No record			....	Still, clear.

Maximum noted for March, *35° C.*, on the 26th at 10 a.m., on Coastal Range near Gulf of Akaba. *Minimum* *7°·2 C.* at 6.50 a.m. on the 13th (head of Wadi Lij), the only case of a record below 10° C.

24 *Morning* Readings gave an average of 16°·4 C., the *Maximum* being *27°·2 C.* at 8 a.m. on the 27th, in Wadi Seyal Noma, and *Minimum.* *7°·2* C. as above.

The *afternoon* temperatures being mostly taken on summits, the *average* is too low, 24 readings giving *22° C.*; the *Maximum* was *35° C.* as above, the *Minimum 16°* at 3.50 p.m. on the summit of Gebel Madsus.

25 *Evening* temperatures give an average of *20°·6 C.*, the *Maximum* being 30°·8 C. at 6 p.m. on the 24, in Wadi Seyal Noma, *Minimum 13°·3 C.* at 8 p.m. on the 13th (head of Wadi Lij).

The month of March was, speaking generally, very equable, temperatures under 10° C. being only recorded once, while there were fifty over 20° C. (35 in the latter half of the month), and seven over 30° C., these latter occurring on the 25th and 26th.

Rain was noted on the 4th, 17th, 18th, and a few drops on the 27th. That of the 4th was connected with a severe thunderstorm, which so far as could be judged (the camp being entirely closed in by hills over 400 metres high), came up from the south, and burst over the Madsus drainage area, no trace of its effects being noted in the neighbouring valleys. This storm was of considerable importance to the expedition, as it filled all the waterpools in a normally waterless district. Like all those seen in Sinai it was marked by brilliant lightning and a torrential downpour of rain, which falling on the bare rock, produces a sound rivalling that of the thunder itself. In a few minutes a rapid torrent of brown mud, over 2 metres wide, was rushing down Wadi Kyd near the camp, but it had disappeared in the morning. On the 5th there was a second storm during the night, but no rain fell at the camp itself. The remaining records are those of ordinary showers.

Wind was recorded on 15 days away from the sea, this being chiefly in the form of afternoon N.E. and E. breezes, but near the Gulf of Akaba there were heavy N.E. and N. winds which blew steadily both day and night.

Cloud or mist was noted on 15 days, heavy clouds being especially marked on the 16th, 17th, and 18th, and again on the 26th and 27th.

Observations for April, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
April 1	7.30 a.m.	18·3	748·4	Near sea, Wadi Gnai El Atshan	Steady N.E. breeze all day on Gulf. Still, clear.
„ 2 & 3	Flying expedition to map in coast. N.E. wind night and day.				
„ 4	7.45 a.m.	19·4	751·5	Wadi Gnai El Atshan	Stiff breeze from N.E. clear.
„ „	1.— p.m.	20	..	Stations 250 metres on Coast range	Wind.
„ „	4.— p.m.	19·7	..		Clear, moderate breeze.
„ „	8.40 p.m.	20·4	753·7	Dahab	Steady N.E. wind and windy night.

Observations for April, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
April 5	6.30 a.m.	17·8	753·9	Dahab.	N.E. breeze.
„ „	8.— a.m.	19·4	754·9	do.	Clear.
„ „	1.40 p.m.	18·9	..	Stations 400 metres above camp	N.E. breeze.
„ „	4.— p.m.	19·4	..		N.E. wind.
„ „	7.30 p.m.	20	753·9	Dahab	N.E. breeze.
„ „	10.30 p.m.	19	754·0	do.	N.E. wind.
„ 6	6.30 a.m.	18·3	754·1	do.	N.E. breeze.
„ „	8.30 a.m.	19·4	754·9	do.	do.
„ „	4.15 p.m.	23·3	752·9	do.	Fresh breeze from N. to N.E.
„ „	5.15 p.m.	22·6	752·4	do.	
„ „	6.50 p.m.	20·3	752·5	do.	....
„ „	10.30 p.m.	20·6	752·7	do.	....
„ 7	7.— a.m.	20·6	751·6	do.	N.E. breeze.
„ „	8.— a.m.	22·1	752·2	do.	Light breeze.
„ „	12.— p.m.	22·1	..	Gebel Tellat Unsair (500 m. above sea)	Clear, light breeze.
„ „	4.— p.m.	23·5	..	Gebel Um Isma	Cloudy, still,
„ „	7.30 p.m.	23·3	741·3	Wadi Abuksheib (mouth)	do.
„ 8	7.45 a.m.	20·6	740·8	do.	Clear.
„ „	11.— a.m.	22·8	741·0	do.	Clear, N.E. breeze.
„ „	2.30 p.m.	23·0	..	Gebel Moghtut (550 metres above valley)	Some clouds.
„ „	6.40 p.m.	22·5	726·4	Wadi Ma'in	Still, clear.
„ 9	7.30 a.m.	22·2	729·3	do.	Strong wind, clear.
„ „	11.— a.m.	21·7	..	Gebel Ma'in (750 metres above valley)	Clear, still.
„ „	1.30 p.m.	22·7	..	do.	N.E. light breeze, clear sky.
„ „	7.30 p.m.	22·2	..	Wadi Ma'in	Gusts of wind.
„ 10	1.20 p.m.	27·8	..	Gebel Um El Wejera (400 metres above valley)	do.
„ „	2.— p.m.	28·3	..	....	Clear, faint N.E. breeze.
„ „	7.— p.m.	24·4	718	Wadi Um Athaga	Still, clear.
„ „	9.30 p.m.	22·2	717·8	do.	do.
„ 11	7.30 a.m.	25	716·5	do.	do.
„ „	12.30 p.m.	25·3	..	Gebel Lij (600 m. above valley)	do.
„ „	3.30 p.m.	24·6	..	do.	Still, little cloud.
„ „	8.— p.m.	26·8	716·4	Wadi Um Athaga	Clear, still.
„ „	10.— p.m.	23·9	716·9	do.	Clear, gusts of wind from N.
„ 12	7.— a.m.	26·3	716·9	do.	Still, cloudy.
„ „	8.— a.m,	26·1	717·4	do.	Still, little cloudy.
„ „	7.30 p.m.	21·1	700·0	Wadi Um Harag	Still, clear.
„ 13	6.30 a.m.	20·0	698·9	do.	do.
„ „	8.— a.m.	21·7	699·4	do.	do.
„ „	12.— p.m.	23·3	..	Gebel Zaraga (over 1000 met. above camp)	N.E. light breeze.

Observations for April, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
April 13	3.— p.m.	21·8	..	....	Clear, few clouds in west.
" "	4.— p.m.	20	..	....	Light breeze.
" "	8.— p.m.	21·7	698·6	Wadi Um Harag	Still, clear.
" 14	12.— p.m.	31·3	697·3	....	do.
" "	4.— p.m.	31·1	..	Station, 200 m. above valley	do.
" "	8.— p.m.	25·6	722·3	Wadi Um Shoka	do.
" "	10.— p.m.	26·1	722·5	do.	do.
" 15	7.— a.m.	26·7	..	do.	do.
" "	12.— p.m.	24·7	..	Gebel Um Shoka El Kebir (900 metres)	do.
" "	3.— p.m.	25	..	do.	do.
" "	8.— p.m.	28·3	713·8	Wadi Um Shoka	Still, clear.
" 16	..	..	..	....	Same as above.
" 17	11.— a.m.	31·3	..	Stations II and III Sheet 16	Still, clear.
" "	1.— p.m.	32·2	..		do.
" 18	10.30 a.m.	30·5	714·4	Wadi Um Shoka	do.
" "	12.— p.m.	31·7	..	Gebel Um Shoka (500 m.)	Light breez ·, east.
" "	1.— p.m.	30·6	..	do.	East breeze, clear.
" "	3.— p.m.	30·0	..	do.	Some clouds coming up.
" "	9.30 p.m.	25·3	713·1	Wadi Um Shoka	Still, clear.
" 19	6.30 a.m.	26·1	713·3	do.	Clear, windy.
" "	7.40 a.m.	28·9	714	do.	Clear.
" "	10.— a.m.	31·1	..	....	East breeze, some clouds.
" "	3.— p.m.	29·2	..	Gebel Jeraimda (400 metres)	Few clouds.
" "	8.— p.m.	25·4	739·7	Wadi Abuksheib	Still, clear.
" 20	7.— a.m.	30·2	740·5	do.	do.
" "	9.30 a.m.	34	..	Sandstone in Wadi Nasb (near 100 metres)	Clear, light breeze from E. to N.E.
" "	1.— p.m.	33·9	..	Station (400 metres)	Light East breeze.
" "	3.30 p.m.	31·1	..	do.	Nearly clear.
" "	8.— p.m.	28·9	734·7	Wadi Nasb (Dahab)	Still, clear.
" 21	8.20 a.m.	33·9	736·4	do.	do.
" "	10.— a.m.	37·2	..	do.	do.
" "	12.30 p.m,	39·5	..	do.	do.
" "	1.— p.m.	39·5	..	do.	East breeze.
" "	2.— p.m.	37·2	735·3	do.	....
" "	8.— p.m.	30·0	735·8	do.	Clear, windy.
" 22	6.— a.m.	25·3	736·4	....	Still, clear.
" "	7.— a.m.	30·0	736·8	....	do.
" "	9.45 a.m.	32·2	..	Station (over 300 metres)	do.
" "	12.— p.m.	33·3	..	do.	Few flaky clouds.
" "	4.— p.m.	30·6	..	Station (600 metres)	Clear, still. Windy Night.
" 23	6.— a.m.	25·6	736·8	Wadi Nasb	Clear, windy.
" "	1.— p.m.	35·8	..	Gebel Um Malaga (700 m.)	Slight haze.

* Heights given above valley level.

Observations for April, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
April 23	2.— p.m.	33·6	..	Gebel Um Malaga (700 m.)	Still, clear sky.
" "	4.— p.m.	32·2	..	do.	do.
" "	8.30 p.m.	28·6	727·4	Wadi Nasb	do.
" 24	7.— a.m.	24·4	727·2	do.	do.
" "	12.— p.m.	36·1	..	Gebel Hammam (500 metres)	do.
" "	4.— p.m.	34	..	do.	do.
" "	8.30 p.m.	30·6	722·8	Wadi Nasb	Strong N.E. wind.
" 25	6.30 a.m.	23·3	723·7	do.	Windy, clear.
" "	10.— a.m.	30·6	..	Station 11, Sheet 16	Clear, light N. breeze.
" "	2.30 p.m.	33·3	..	do.	....
" "	Evening	28·9	..	Wadi Nasb	Windy.
" 26	6.30 a.m.	21·7	722·8	do.	Still, clear.
" "	7.— a.m.	29·4	723·3	do.	Still, clear, clouding.
" "	4.— p.m.	25·6	..	Gebel Gurna (700 metres)	Clouded, but not entirely.
" "	7.— p.m.	26·1	706·8	Wadi Nasb	Still, heavily clouded.
" 27	6.30 a.m.	23·7	709·09	Wadi Nasb (E. bend) and Wadi Thaiyib Tissim	Still, quite clouded over.
" "	2.30 p.m.	32·2	..	Gebel Thaiyib Tissim (450)	Clouds clearing away. S.E. breeze.
" "	7.30 p.m.	28·6	706·6	Wadi Nasb (as above)	Still, nearly clear.
" 28	1.— p.m.	29·4	..	{ Stations Gebel Sadagiya,	S.E. breeze, clear
" "	3.— p.m.	28·3	..	{ etc... (500 metres)	sky.
" "	9.— p.m.	25·4	695·8	Wadi Nasb and Wadi Meer	Still, clear.
" 29	7.30 a.m.	30·0	695·8	do.	do.
" "	11.— a.m.	30·6	..	Gebel Rubha (600 metres)	do.
" "	1.— p.m.	30·8	..	do. (higher peak)	West breeze.
" "	7.30 p.m.	27·7	694·8	Wadi Nasb and Wadi Mir	Still, clear.
" 30	7.30 a.m.	21·7	696·9	do.	Clear, breeze.
" "	10.45 a.m.	22·2	..	Gebel Adiebat (800 metres)	Clear, N. breeze.
" "	12.40 p.m.	24·7	..	do.	....
" "	3.30 p.m.	22·6	695·8	Wadi Nasb and Wadi Meer	Still, clear, hazy in evening.

* Heights given above valley level.

The Maximum recorded for the month of April was 39°·5 C. (103 F.) between 12.30 and 1 p.m. on the 21st in Wadi Nasb (Dahab), the Minimum 17°·8 C. at 6.30 a.m. on the 5th at Dahab.

The Morning Averages (31 readings)=23°·5 C., the Maximum being 33.9 at 8.20 a.m. on the 21st, and 30.2 at 7 a.m. on the 20th, in Wadi Abuksheib, the Minimum 17°·8 C.

The Afternoon Averages practically are those for heights of 1000 metres above sea-level, or 500 above valley-level=24°·6 C., the Maximum record was 39°·5 C., the minimum 19°·4 C. on the 5th, 4 p.m. (hills west of Dahab).

The Evening Average (mainly between 7 and 8 p.m.)=24.8 C. Maximum 30°·6 at 8.30 p.m., 24th, Wadi Nasb. Minimum 18°·3 C. at 7.30 p.m. on the 1st at mouth of Wadi Gnai El Atshan. The morning averages alone are therefore useful for comparison with previous months.

Rain was entirely absent, heavy cloud also being rare, 7th, 8th, 12th, 19th, 26th and 27th, being nearly the only records. The Wind record, on the contrary, is high, during the first seven days, which were spent on the Gulf of Akaba, there being practically no cessation day or night, it throughout blowing from the N.E., or down the Gulf. For fifteen days breezes were noted, mostly light N.E. and in the afternoon, but on the night of the 22nd and evening of the 24th, the force was much greater. Owing to the prevalent direction of the air currents, their movements are much more noticeable in the north and south rifts, such as the Gulf of Akaba and the parallel valleys in East Sinai, than in the Transverse Valleys.

April may be said to have marked the distinct change to summer conditions, temperatures above 30° C. being recorded three times in the morning, 11 times afternoon, twice in the later evening, about eight.

Observations for May, 1899.

Date		Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899						
May	2	7.30 a.m.	21·1	697·9	Wadi Nasb and Wadi Mir	Clear, still.
„	„	10.10 a.m.	23·3	690·5	North bend of Nasb	Clear, then N. breeze (3.30).
„	3	7.— a.m.	22·8	710·1	Wadi Thaiyib Tissim and Nasb	Still, clear.
„	„	11.15 a.m.	27·3	..	Wadi Nasb	N.E. breeze, clear.
„	„	1.— p.m.	28·9	..	do.	Clear sky,
„	„	4.30 p.m.	25·6	..	do.	N.E. breeze, clear sky
„	4	1.— p.m.	28·3	..	Station (300 metres)	Still, clear.
„	„	4.— p.m.	26·4	..	do.	N.E. breeze, clear sky. light haze.
„	„	7.40 p.m.	21·7	696·2	Plain of Barga	Still, clear.
„	5	7.20 a.m.	18·3	697·3	do.	do.
„	„	11.— a.m.	23·3	..	Gebel Um Ushtan (300 m.)	N. breeze, clear.
„	„	1.— p.m.	26·1	..	do.	Clear.
„	„	4.30 p.m.	23·7	..	do.	N. breeze, clear.
„	6	7.40 a.m.	21·7	702·8	Wadi Hammam	Clear, still.
„	„	12.15 p.m.	28·3	..	Gebel El Araish (250 metres)	Clear, N. breeze.
„	„	2.30 p.m.	29·4	..	do.	do.
„	„	7.— p.m.	24·4	700·4	Wadi Hammam	Still, clear.
„	7	6.30 a.m.	17·8	700·8	do.	do.
„	„	7.20 a.m.	22·2	701·5	do.	do.
„	„	12.— p.m.	25·6	..	Gebel Barga (300 metres)	Moderate N. breeze.
„	„	1.30 p.m.	27·2	..	do.	do.
„	„	4.30 p.m.	26·1	..	do.	do.
„	„	7.30 p.m.	23·3	694·5	Plain of Barga	North breeze, clear.

* Heights given above valley level.

Observations for May, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
May 7	9.— p.m.	22·2	695·4	Plain of Barga.	Slight breeze, clear.
„ 8	6.20 a.m.	17·2	694·2	do.	Clear, still.
„ „	7.— a.m.	23·3	694·8	do.	do.
„ „	10.— a.m.	27·8	..	Station (200 metres).	N. breeze, clear.
„ „	11.30 a.m.	29·7	..	do.	Few thin clouds coming from west.
„ „	2.— p.m.	35·3	..	Gebel Um Raiyig (200).	
„ „	5.— p.m.	31·1	..	do.	....
„ „	9.30 p.m.	23	691·9	Wadi Somra	Still, clear.
„ 9	6.20 a.m.	20	692·0	do.	do.
„ „	7.20 a.m.	27·2	693·0	do.	do.
„ „	9.45 a.m.	33·9	..	Low Stations	Thin clouds.
„ „	1.— p.m.	33·9	..		
„ „	3.40 p.m.	32·8	..		Still, cloudy.
„ „	7.30 p.m.	28·3	687·9	Wadi Amutamir	....
„ 10	7.30 a.m.	27·2	669·4	do.	Clear, still.
„ „	11.— a.m.	33·0	..	Station (150 metres)	Some thin clouds, light North breeze.
„ „	3.— p.m.	30·6	..	Gebel Gunna (400 metres)	North wind.
„ 11	8.— a.m.	25·6	686·6	Plain at foot of Gunna	....
„ „	9.40 a.m.	31·7	..	....	N. breeze.
„ „	2.— p.m.	33·9	..	....	N. breeze, sky full of white fleeces.
„ „	5.30 p.m.	29·4	..	....	Strong N. wind, with stormy clouds.
„ „	9.— p.m.	27·5	688·4	Wadi Hejaj	N. wind, clouds.
„ 12	7.30 a.m.	27·2	688·4	Near Ain El Hudera	Still, clear.
„ „	11.40 a.m.	34·2	..	Stations 200 metres above valley	N.E. wind, clear.
„ „	12.30 p.m.	36·4	..	Gebel Hudera	....
„ „	1.30 p.m.	33·9	..		N. E. breezes, white fleeces.
„ „	3.30 p.m.	32·8	..		White clouds. Heavy clouds at 6 p.m.
„ „	7.— p.m.	27·2	688·2	Near Ain El Hudera	Cloudy.
„ 13	11.30 a.m.	36·1	..	Ain El Hudera	N.E. breeze, white clouds.
„ „	12.30 p.m.	35·6	..	do.	Strong West wind, heavy clouds and showers.
„ 14	?6.— a.m.	22·8	693·2	Wadi Ejjibi	Clear, still.
„ „	7.30 a.m.	27·8	..	do.	do.
„ „	10.30 a.m.	33·3	..	Low Stations	do.
„ „	6.— p.m.	31·1	..		Windy.
„ „	9.— p.m.	27·9	695·0	Wadi Um Rowa	do.
„ 15	7.30 p.m.	27	707·6	Junction of Wadi Raib and Wadi Abu Lassaf	N.W. wind in day. Little wind.
„ 16	7.30 a.m.	24·7	708·0	do.	Still, clear.
„ „	11.30 a.m.	29·3	..	Gebel Kharaza (400 metres)	do.
„ „	1.30 p.m.	30·6	..	do.	Still, clear.

* Heights given above valley level.

Observations for May, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
May 17	Evening	29·7	..	Wadis Raib and Abu Somra	West wind, clear.
„ „	10.30 a.m.	25·6	714·8	do.	N. breeze, clear.
„ „	12.— p.m.	26·4	..	Gebel Abu Somra (500 metres)	N. breeze, clear.
„ „	1.— p.m.	29·4	..		do.
„ „	3.30 p.m.	27·2	..		Still, clear.
„ „	7.— p.m.	27·2	713·4	Wadi Abu Somra and Wadi Raib	do.
„ 18	7.30 a.m.	24·8	724·7	Wadi Kharaza	Clear, still, all day.
„ 19	7.30 a.m.	28·3	..	do.	Still, clear.
„ „	11.30 a.m.	34·4	..	Gebel Abu Habba (500 metres), and another Station	N. E. breeze.
„ „	1.— p.m.	32·8	..		....
„ „	3.— p.m.	33·2	..		Still, clear in evening.
„ 20	11.— a.m.	12·4	..	Top of Mt. Sinai	....
„ 26	11.— a.m.	25·8	750·2	Tor camp	Clear, still.
„ „	11.45 p.m.	25·3	749·3	do.	N.W. breeze.
„ 27	9.— a.m.	25·3	750·6	do.	....
„ „	5.30 p.m.	29·2	748·8	do.	Stiff N.W. breeze.
„ 28	9.30 a.m.	25·8	751·2	do.	....
„ „	10.— p.m.	25·3	749·1	do.	....

* Heights given above valley level.

For the first nineteen days of May (excluding 1st) the *Maximum* record was 36°·4 C. at 12.30 p.m. on the 12th at Ain El Hudera, the *Minimum* 17°·2 C. at 6.20 a.m. on the 8th (plain of Barga).

Average for *Morning* (12 readings)=22°·6 C. *Maximum* 28°·3 C. at 7.30 a.m. on the 19th (in Wadi Raib). *Minimum* 17°·2 as above. The average is too high, as this month there was considerable difference between readings made at 6 and 7 a.m. respectively.

Afternoon Average (15 readings)=31°9 C. *Maximum* 36°4 C. as above. *Minimum*= 26°1 C. at 1 p.m. on Gebel Um Ushtan.

Evening Average=27°·1 C. (11 readings). *Maximum* 37°·1 C. at 5 p.m. on 8th on Gebel Um Raiyig, and 6 p.m. on the 14th on plateau above Wadi Um Rowa. *Minimum* 21°·7 C. on the 4th in the plain of Barga. Only 12°·4 C. was noted on the summit of Sinai on the 22nd. Showers fell on the 13th, and between the 10th and 15th several storms were seen to pass over Sinai and the Abu Mesùd district.

In the afternoons N.E. breezes were common, accompanied by thin clouds; after the 15th, west winds began to be noted, and at Tor these were blowing with great regularity. Heavy clouds were only recorded from the 11th to the 13th.

APPENDIX II.

The writer, acting under the advice of botanical friends, had originally proposed making the appended list the basis for a critically studied florula of the Sinai peninsula. Owing to the pressure of other work, this aim has to be abandoned, and the list, as originally prepared, is inserted without amendment, in the hopes that it may prove of some use to those working at the wider question of plant-distribution. On it are based any of the wider conclusions drawn in the botanical section, which for the same reasons as those above given, has also to be published in its present form.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA.

Natural Order	Plant	Arabic Name	Distribution	Collection
I.—PAPAVERACEÆ.				
1. *Papaveraceæ.*	*Papaver Decaisnei*, Hochst. and Steud.	....	Wadi Tarfa.	Kneucker Coll.
2. do.	*Rœmeria dodecandra*, (Forsk.) Fedde.	....	In valleys and plains near Sinai.	Do.
3. do.	*Do.* var. *pinnatifida* (Boiv.) Boiss.	....	Gebel Katharina at 2,450 met.	Do.
4. do.	*Glaucium arabicum*, Fresen.	No'man.	Wadi Tarfa (1,100 metres).	Do. and Ord. Surv.
5. do.	*Glaucium grandiflorum*, Boiss. et Huet.	....	Near Sinai convent (1,500 m.)	Kneucker Coll.
6. do.	*Hypecoum pendulum*, L.	Salîhh.	Ditto.	Do. P.F.
II.—FUMARIACEÆ.				
7. *Fumariaceæ.*	*Fumaria parviflora*, Lam.	....	One specimen Gebel Katharina, 1800-1900 metres.	Do.
III.—CRUCIFERÆ.				
8. *Cruciferæ*	*Morettia philæana* (Del.), D.C.	....	Qa'a plain.	Do.
9. do.	*Morettia canescens*, Boiss.	Rakhmi.	Sinai generally.	Do. and Ord. Surv.
10. do.	*Morettia parviflora*, Boiss.	....	Once only, between Feirân and Maghara.	Kneucker Coll.

NOTE.—K.C.=Kneucker Coll. P.F.=Post's Flora. Ord. Surv.=Ordnance Survey.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA— (*continued*).

Natural Order	Plant	Arabic Name	Distribution	Collection
III.—CRUCIFERÆ (*cont.*)				
11. *Cruciferæ*.	*Matthiola arabica*, Boiss.	Ghomghom.	Sinai generally.	Hume Coll. K.C.
12. do.	*Matthiola livida* (Del.), Boiss.	....	Ditto.	Kneucker Coll.
13. do.	*Eremobium ægyptiacum*, (Spreng.)	....	In sandy places. Wadis Werdan and Gharandel.	Kneucker Coll., P.F.
14. do.	*Eremobium lineare* (Del.), Boiss.	Samih or Qabah.	Feiran Oasis, in sandy places.	Do. P.F.
15. do.	*Farsetia ægyptiaca*, Turr.	....	Especially between Wadis Werdan and Gharandel.	Do. O.S.
16. do.	*Arabis auriculata*, Lam.	....	Small plant growing under granite boulders (Gebel Katharina, etc.).	Do.
17. do.	*Sisymbrium Schimperi*, Boiss.	....	Jebels Musa and Katharina..	Do. P.F.
18. do.	*Sisymbrium Kneuckeri*, Bornm.	....	Foot of Gebel Katharina, 1800-1850 m.	Do.
19. do.	*Sisymbrium* f. *aprica*.	....	Foot of Gebel Serbal, 1100-1400 m.	Do.
20. do.	*Sisymbrium rigidulum*, Decsn.	Salih	Southwest and Central Sinai, 400-1500 m.	Do. P.F.
21. do.	*Sisymbrium erysimoides*, Dsf.	Thuwwat	Feiran Oasis and foot of Serbal (600-750 m.).	Do. P.F.
22. do.	*Sisymbrium iris*, L.	....	Wadi Tarfa and plain of Er Raha.	Do.
23. do.	*Malcolmia africana*, (L.) R.Br.	....	Various places from 600-2450 metres.	Do.
24. do.	*Alyssum marginatum*, Steud.	....	Near Sinai Convent 1500 m.	Do.
25. do.	*Clypeola microcarpa*, Moris.	....	Stony places, Sinai.	Do. P.F.
26. do.	*Clypeola jonthlaspi*, L.	....	Hills and sandy places.	Post's flora.
27 do.	*Notoceras Canariensis*, R.Br.	....	From Serbal to Wadi Shellal, 200-750 m.	Kneucker Coll.
28. do.	*Isatis microcarpa*, J. Gay.	....	Wadi Tarfa 1100-1200 m. and Wadi Seba'iaa.	Do. P.F.
29. do.	*Moricandia Sinaica*, Boiss.	Khusian el Jemel or Yahag.	Wadi Isla, 200-500 m. also in Wadi El Sheikh.	Do. P.F.
30. do.	*Moricandia dumosa*, Boiss.	Hhamimah.	....	Post's flora.
31. do.	*Moricandia clavata*, Boiss. et Rent.	....	....	Do.

				especially Wadi Letih.	Colls., K.C.
33.	do.	*Diplotaxis acris*, Forsk.	Shuqaiyar.	Wadi El Sheikh.	Kneucker Coll.
34.	do.	*Brassica Tournefortii*, Gou.	....	Cultivated. Wadi Feiran 600 metres.	Do.
35.	do.	*Savignya Ægyptiaca*, D.C.	Hhalawah.	Wadi Isla and Gharandel.	Do. P.F.
36.	do.	*Zilla myagroides*, Forsk.	Bsilla.	Ubiquitous.	Hume Coll. K.C.
37.	do.	*Anastatica hierochuntina*, L.	....	On coral reefs between Nebk and Sherm.	Do.
38.	do.	*Carrichthera vellæ*, D.C.	....	....	Post's flora.
39.	do.	*Kœniga arabica*, Boiss.	Dhahhiyan.	....	Do.
40.	do.	*Schimpera arabica*, Hochst et St.	Es Sufeira.	....	Do.
41.	do.	*Enarthrocarpus strangulatus*, Boiss.	Shilwat or Yasanid.	....	Do.
42.	do.	*Hussonia uncata*, Boiss.	....	....	Do.
43.	do.	*Schouwia arabica*, D.C.	Nam-nam	....	Hume Coll.
	IV.—CAPPARIDACEÆ.				
44.	*Capparidaceæ*,	*Cleome arabica*, L.	Janinah Zifrah or Shajarat wahhsh (P.F.)	(O.S.) also Um Rumail.	Kneucker, Coll. O.S.
45.	do.	*Cleome trinervia*, Fresen.	....	Wadi Isla.	Do. O.S.
46.	do.	*Cleome brachycarpa*, Val.	Berberan.	Sinai near Red Sea.	Post's flora.
47.	do.	*Cleome droserifolia*, Del.	? Sommu, Rihh-el-bard (P.F.)	Common in south-east Sinai.	Hume Coll.
48.	do.	*Cleome chrysantha*, Den.	Sufeir atan.	Invading southern form.	Ord. Survey.
49.	do.	*Capparis spinosa*, L.	Lassaf.	In mountain ravines.	Hume Coll.
50.	do.	*Mærua uniflora*, Vahl.	....	....	Post's flora.
	V.—RESEDACEÆ.				
51.	*Resedaceæ*.	*Ochradenus baccatus*, Del.	Gurdi.	Common in the mountain valleys.	Hume Coll. K.C.
52.	do.	*Reseda propinqua*, R.Br.	....	Wadi Aleyat (Serbal), 650-755 m.	Kneucker Coll. P.F.
53.	do.	*Reseda arabica*, Boiss.	....	Wadis Werdan and Gharandel.	Do. P.F.
54.	do.	*Reseda pruinosa*, Del.	Kazum.	Wadi Tarfa and El Sheikh.	Do. P.F.
55.	do.	*Reseda stenastachya*, Boiss.	....	Sinaitic valleys.	Post's flora,
56.	do.	*Reseda muricata*, Presl.	....	....	Do.
57.	do.	*Caylusea canescens*, (L.) S. Hil.	....	Ubiquitous.	Kneucker Coll. P.F.
58.	do.	*Oligomeris subulata*, Del.	....	....	Post's flora.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plants.	Arabic Names	Distribution.	Collection.
VI.—CISTACEÆ.				
59. *Cistaceæ.*	*Helianthemum ventosum*, Boiss.	Ra'r.	Wadi el Akhdar.	Barron Coll. K.C.
60. do.	*Helianthemum kahiricum*, Del.	Girsum	Between Wadi Werdan and Gharandel.	Kneucker Coll. O.S.
61. do.	*Helianthemum Sancti Antonii*, Schweinf.	....	Foot of Serbal. 1100-1400. m.	Do.
62. do.	*Helianthemum Lippi*, (L.) Boiss. Y. *micranthum* Boiss.	....	Stony places.	Do.
63. do.	*Helianthemum vesicarium*, Boiss.	....	....	Post's flora.
VII.—SILENACEÆ.				
64. *Silenaceæ.*	*Tunica arabica*, Boiss.	....	Wadi Aleyat (Serbal) 650-750 m.	Kneucker Coll.
65. do.	*Dianthus Libanotis*, Labille.	....	Mount St. Katharina.	Post's flora.
66. do.	*Dianthus sinaicus*, Boiss.	Sammah.	Rocks at base of Sinai.	Do.
67. do.	*Gypsophila Rokejeka*, Del.	Sirr.	Dry places and high mountain plateaux.	Hume Coll.
68. do.	*Gypsophila elegans*, M.B.	....	Between Wadis Werdan and Gharandel.	Kneucker Coll. P.F.
69. do.	*Gypsophila hirsuta*, var. *alpina*, Boiss.	....	Gebel Katharina.	Post's flora.
70. do.	*Silene eremophila*, Bienert.	....	Sandy and gravelly places: Wadi Tarfa, etc.	Kneucker Coll.
	Silene odontopetala, Fenzl.	....	....	....
	Silene congesta, Boiss.	Mt St Katharina.	....	....
71. do.	*Silene apetala*, Willd.	....	Feiran Oasis.	Kneucker Coll.
	Silene conoidea, L.	....	....	Boissier.
72. do.	*Silene villosa*, Forsk.	Nimwar Atani, etc.	Debbet er Ramleh.	Barron Coll.
	Silene schimperiana, Boiss.	....	....	Boissier Coll.
73. do.	*Silene arabica*, Boiss.	....	Sands, Sinai.	Post's Flora.
	Silene oliveriana, Otth.	....	Arabia Petræa.	Boissier Coll.
74. do.	*Silene bipartita*, var, *stenophylla* Boiss.	....	....	Do.
75. do.	*Silene Hussoni*, Boiss.	....	....	Do.
	Silene linearis, Decn.	....	Arabia Petræa.	Do.

76.	do.	***Silene leucophylla***, **Boiss.**	....	**Gebel Katharina.**	Boissier Coll.	
76*a*.	do.	***Buffonia multipes***, Desn.,	....	Foot of Gebel Katharina, etc.	Kneucker Coll.	
VIII.—Alsineæ.						
77.	*Alsineæ.*	*Alsine brevis*, Boiss.	....	Er Raha plain.	Kneucker Coll.	P.F.
78.	do.	*Alsine picta*, var. *sinaica*, Boiss.	Quleiqalah.	Sinai valleys.	Do.	P.F.
79.	do.	*Holosteum liniflorum*, Stev.	....	Do.	Do.	P.F.
80.	do.	*Cerastium viscosum*, L.	....	Feiran Oasis.	Do.	
81.	do.	*Spergularia diandra* (Guss.) Boiss.	....	Do.	Do.	
IX.—Paronychiaceæ.						
82.	*Paronychiaceæ.*	*Robbairea prostrata* (Forsk.), Boiss.	Enjiadeh and numerous other names.	Ubiquitous.	Hume Coll.	K.C.
83.	do.	*Polycarpæa fragilis*, Del.	Qumeilah or Makk.	Widely distributed.	Kneucker Coll.	P.F.
84.	do.	*Herniaria hemistemon*, Gay.	Um Libbaideh.	Wadi Gharandel and Wadi Werdan.	Do.	P.F.
85.	do.	*Paronychia lenticulata*, (Forsk.) Aschers. and Schweinf.	....	Between Wadi Feiran and Maghara.	Do.	
86.	do.	*Paronychia sinaica*, Fresen.	....	Sinai Monastery.	Do.	P.F.
87.	do.	*Paronychia desertorum*, Boiss.	Rukhaimah or Libbeit.	On sands.	Post's flora.	
88.	do.	*Gymnocarpus fruticosum*, Pers.	....	Wadi Isla and foot of Serbal, 1100-1400 m.	Kneucker Coll.	
89.	do.	? *Gymnocarpus decander.*	Djeradeh.	Hill shrub in Um Zeinig and Gnai.	Hume Coll.	
90.	do.	*Pteranthus echinatus*, Desf.	....	Foot of Serbal.	Kneucker Coll.	P.F.
91.	do.	*Cometes abyssinica*, R. Br.	....	Wadi Isla (Southern Sinai).	Do.	P.F.
92.	do.	*Polycarpon arabicum*, Boiss.	....	....	Post's flora.	
93.	do.	*Polycarpon succulentum*, Del.	....	....	Do.	
94.	do.	*Sclerocephalus arabicus*, Boiss.	....	....	Do.	
X.—Mollugineæ.						
95.	*Mollugineæ.*	*Telephium sphærospermum*, Boiss.	....	Wadi Sheikh and Wadi Hebran.	Do.	
96.	do.	*Glinus*, sp.	Lepetha.	....	Hume Coll.	
XI.—Tamariscineæ.						
97.	do.	*Reaumuria hirtella*, Jaub. et sp.	Mellâhh.	Wadi Gharandel.	Kneucker Coll.	P.F.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XI.—TAMARISCINEÆ—(*cont.*)				
98. *Tamariscineæ.*	*Reaumuria palæstina*, Boiss.	....	....	Post's flora.
	Tamarix tetragyna, Ehrenb.	....	....	Boissier Coll.
99. do.	*Tamarix mannifera*, Ehr.	Tarfa.	Ubiquitous.	Ord. Serv.
100. do.	*Tamarix articulata*, Vahl.	....	....	Do.
XII.—HYPERICINEÆ				
101. *Hypericineæ.*	*Hypericum sinaicum*, Hochst.	....	Moist rocks.	Post's flora.
XIII.—MALVACEÆ.				
102. *Malvaceæ.*	*Althæa Ludwigii*, L.	....	....	Do.
103. do.	*Alcea striata*, D.C.	Khutmi.	Valley of Rephidim.	Do.
104. do.	*Malva ægyptia*, L.	Khubbaizeh.	....	Do.
105. do.	*Malva rotundifolia*, L.	....	Wadi Letih.	Hume Coll.
106. do.	*Malva parviflora*, L.	....	Near Sinai Convent and Wadi Feiran.	Kneucker Coll.
107. do.	*Sida rhombifolia*, L.	....	....	Post's flora.
108. do.	*Abutilon fruticosum*, Guill. et Perr.	....	On rocks.	Do.
109. do.	*Hibiscus ovalifolius*, Vahl.	Khutmi.	Do.	Do.
XIV.—TILIACEÆ.				
110.—*Tiliaceæ.*	*Grewia populifolia*, Vahl.	....	....	Do.
XV.—GERANIACEÆ.				
111. *Geraniaceæ.*	*Erodium cicutarium*, L.	....	....	Kneucker Coll. O.S.
112. do.	*Erodium laciniatum*, Cav.	....	{ Wadi Sig. { Er Raha Plain.	Barron Coll. Kneucker Coll.
113. do.	*Erodium laciniatum*, var. *pulverulenta*, (Desf.) Boiss.	Ujreiyat-el-Ghazal.	Near Sinai Convent and Feiran Oasis.	Do. P.F.
114. do.	*Erodium glaucophyllum*, Ait.	Kabshiyah, etc.	Between Wadis Gharandel and Werdan.	Do. P.F.
115. do.	*Erodium bryoniæfolium*, Boiss.	Dehamin or Murghit.	Er Raha Plain and Wadi El Sheikh.	Do. P.F.
[illegible]	[illegible] Forsk.	Tummeir or Bislia	Dabbet-er-Ramleh.	Barron Coll.

120.	do.	*Tribulus terrestris*, L.	Aleig.	Qa'a Plain.	Do.	P.F.
120*a*.	do.	*Tribulus alatus*, Del.	Dreisi.	....	Hume Coll.	
121.	do.	*Fagonia glutinosa*, Del.	Shika'ah or Medahin.	Between Wadis Gharandel and Werdan.	Kneucker Coll.	P.F.
122.	do.	*Fagonia myriacantha*, Boiss.	....	Wadis Isla, Tarfa.	Do.	P.F.
123.	do.	*Fagonia mollis*, Del.	....	Wadi Isla.	Do.	O.S.
124.	do.	*Fagonia sinaica*, Boiss.	....	Feiran Oasis.	Do.	P.F.
125.	do.	*Fagonia cretica*, L.	....	....	Post's flora.	
126.	do.	*Fagonia Bruguieri*, D.C.	....	....	Do.	
127.	do.	*Fagonia arabica*, L.	Aqul.	....	Ord. Surv.	
128.	do.	*Fagonia cistoides*, Del.	Oward.	....	Do.	
129.	do.	*Zygophyllum simplex*, L.	....	Feiran Oasis.	Kneucker Coll.	O.S.
130.	do.	*Zygophyllum album*, L.	....	Near sea-coast from Tor to Wadi Werdan.	Do.	
131.	do.	*Zygophyllum coccineum*.	Ratreet.	Ras Mohammed.	Hume Coll.	
132.	do.	*Peganum harmala*, L.	Haremlan.	Between Wadis Tarfa and Rutig.	Kneucker Coll.	
133.	do.	*Nitraria tridentata*, Desf.	Gharqad.	Common in large valleys and on seashore.	Hume Coll.	K.C.
134.	do.	*Seetzenia orientalis*, Dec.	Habein.	....	Post's flora.	
	XVII.—RUTACEÆ.					
135.	*Rutaceæ*.	*Haplophyllum tuberculatum* (Forsk).	Mugennineh.	....	Ord. Surv.	
	XVIII.—RHAMNACEÆ.					
136.	*Rhamnaceæ*.	*Zizyphus Spina-Christi*, (L.) β. *inermis*, Boiss.	Sidri.	Feiran Oasis and Wadi Kyd.	Hume Coll.	K.C.
	XIX.—MORINGEÆ.					
137.	*Moringeæ*.	*Moringa aptera*, Gaertn.	Ban.	Wadi Hebran.	Barron Coll.	
	XX.—LEGUMINOSÆ.					
138.	*Leguminosæ*.	*Lotononis leobordea*, Benth.	....	Lower Wadi Isla and Er Raha Plain.	Kneucker Coll.	
139.	do.	*Lotononis dichotoma*, Del.	Hhurbut.	....	Post's flora.	
140.	do.	*Lotononis* do., var. *persica*, Post.	....	....	Do.	
141.	do.	*Retama roetam*, Forsk.	Retem.	Common in North Sinai, rare in South portion.	Hume Coll.	K.C.
142.	do.	*Trigonella stellata*, Forsk.	....	....	Barron Coll.	K.C.
143.	do.	*Trigonella arabica*, Del.	....	....	Do.	
144.	do.	*Trigonella microscarpa*, Fresen.	G'rieh.	....	Ord. Surv. Coll.	
145.	do.	*Melilotus Indica*, All.	....	Moist places in Feiran Oasis.	Kneucker Coll.	

List of Plants noted in the Sinai Peninsula—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XX.—Leguminosæ.—(*cont*).				
146. *Leguminosæ.*	*Lotus arabicus*, L.	Gathbi.	Wadi Tarfa, etc.	Hume Coll. K.C.
147. do.	*Lotus glinoides*, Del.	....	....	Post's flora.
148. do.	*Psoralea bituminosa*, L.	Samar.	....	Ord. Surv. Coll.
149. do.	*Psoralea Palæstina*, L.	....	Wadi Tarfa.	Kneucker Coll.
150. do.	*Colutea Haleppica*, Lam.	Qasnur.	Foot of Gebel Serbal.	Do. P.F.
151. do.	*Astragalus prolixus*, Sieb.	....	Lower Wadi Isla.	Do.
152. do.	*Astragalus tribuloides* Del.	Rukhaimi or Qudad.	Sandy places in Wadi Tarfa, Sinai, and foot of Serbal.	Do. P.F.
153. do.	*Astragalus corrugatus*, Bert.	....	Lower Wadi El Sheikh.	Do. P.F.
154. do.	*Astragalus* do., var *brevipes*, Post.	....	Wadi Feiran.	Post's flora.
155. do.	*Astragalus bombycinus*, Boiss.	Durreis or Khansarat el Arus.	Fairly common.	Kneucker Coll. P.F.
156. do.	*Astragalus Fresenii*, Den.	Agfur.	Near Sinai Convent.	Do. P.F.
157. do.	*Astragalus sparsus*, Dec.	....	Among granite boulders at foot of Serbal.	Do. P.F.
158. do.	*Astragalus Sieberi*, D.C.	Qudad, etc.	Widely distributed.	Post's flora.
159. do.	*Astragalus echinus*, D.C.	....	On Gebel Musa (ab. 2100 m.) and Gebel Katherina (ab. 2450 m.).	Kneucker Coll.
160. do.	*Astragalus Forskhalei.*	Thimrah.	Near Foot of Serbal.	Do. P.F.
161. do.	*Astragalus Kneuckeri*, Freyn.	....	Between Wadi Tarfa and Gebel Musa.	Do.
162. do.	*Astragalus arabicus*, Ehr.	....	....	Post's flora.
163. do.	*Astragalus pseudostella*, Del.	....	....	Do.
164. do.	*Astragalus Schimperi*, Boiss.	Qureidun aswad.	....	Do.
165. do.	*Astragalus eremophilus*, Boiss.	Um-el-Qurein, etc.	....	Do.
166. do.	*Astragalus tenuirugis*, Boiss.	....	....	Do.
167. do.	*Astragalus Gyzensis*, Del.	Adham el Farah.	....	Do.
168. do.	*Astragalus hispidulus*, Astr.	....	....	Do.
169. do.	*Astragalus acinaciferus*, Boiss.	....	....	Ord. Surv. Coll.
170. do.	*Astragalus trigonus*, D.C.	....	....	Post's Flora.
171. do.	*Astragalus Kahiricus*, D.C.	Asabi-el-Arus.	Debbet-er-Ramleh.	Do.
172. do.	*Astragalus tumidus*, Willd.	Kedad.	....	Ord. Surv. Coll.
173. do.	*Onobrychis Ptolemaica*, Del.	Khansar-el-Arus.	Er Raha Plain, Wadi el Sheikh,	Kneucker Coll. O.S.

175.	do.	*Cassia obovata*, Collad.	Senna.	Wadi Nasb and north of it.	Hume Coll. K.C.
176.	do.	*Cassia lanceolata*, Forsk.	Senna Sa'idi or Lisan-el-Asfur.	....	Post's Flora.
177.	do.	*Acacia tortilis*, Hayne.	Seyal.	Ubiquitous.	Kneucker Coll. P.F.
178.	do.	*Acacia Seyal*, Del	Do.	Do.	Post's Flora.
179.	do.	*Acacia nilotica*, De.	Sunt.	Southern Sinai.	Do.
180.	do.	*Crotalaria ægyptiaca*, Benth.	Natash.	Probably abundant in East Sinai.	Do.
181.	do.	*Argyrolobium uniflorum*.	....	....	Do.
182.	do.	*Ononis reclinata*, var. *minor*, Boiss.	....	....	Do.
183.	do.	*Medicago laciniata*, var. *brachyacantha*, Boiss.	....	....	Do.
184.	do.	*Medicago Aschersoniana*, Urban.	....	....	Do.
185.	do.	*Indigofera arabica*, Jaub. et Sp.	....	....	Do.
186.	do.	*Tephrosia purpura*, Pers.	....	....	Ord. Surv. Coll.
187.	do.	*Tephrosia apollinea*, Del.	Amyanah.	....	Post's Flora.
	XXI.—ROSACEÆ.				
188.	*Rosaceæ*.	*Pirus communis*, L. f. *vergens ad cordatum* (*Desv.*)	....	Foot of Ras Safsaf.	Kneucker Coll.
189.	do.	*Neurada procumbens*, L.	....	Between Wadi Feiran and Maghara and Wadi Shellal.	Do. O.S.
190.	do.	*Rosa arabica*, Crep.	....	Mount St Katharine.	Post's Flora.
191.	do.	*Poterium verrucosum*, Spach.	Dhwaint-el-far or erbaiyan.	....	Ord. Surv. Coll.
192.	do.	*Cratægus aronia*, Bosc.	Za'rut.	....	Do.
		Cratægus sinaica, Boiss.	Za'rur.	....	Post's Flora.
	XXII.—CRASSULACEÆ.				
193.	*Crassulaceæ*.	*Cotyledon umbilicus*, L.	....	....	Ord. Surv. Coll.
	XXIII.—CUCURBITACEÆ.				
194.	*Cucurbitaceæ*.	*Cucumis prophetarum*, L.	Nafi'ah or Honedlai.	Ubiquitous.	Kneucker Coll. P.F.
195.	do.	*Citrullus colocynthis*, L.	Handal.	Do.	Do. O.S.
	XXIV.—FICOIDEÆ.				
196.	*Ficoideæ*.	*Aizoon Canariense*, L.	....	Feiran Oasis.	Kneucker Coll.
197.	do.	*Aizoon hispanicum*, L.	Ghassul.	....	Post's Flora.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XXV.—UMBELLIFERÆ.				
198. *Umbelliferæ.*	*Deverra tortuosa*, (Desf.) Boiss.	Qasuch.	Between Wadi Werdan and Wadi Gharandel.	Kneucker Coll. P.F.
199. do.	*Scandix pinnatifida*, Vent.	....	Round Sinai Convent in small plants.	Do.
200. do.	*Pycnocycla tomentosa*, Dec.	Sellam.	....	Ord. Surv. Coll.
201. do.	*Bupleurum linearifolium*, var. *Schimperianum*, Boiss.	....	....	Post's Flora.
202. do.	*Pimpinella cretica*, var. *arabica*, Boiss.	....	....	Do.
203. do.	*Ferula sinaica*, Boiss.	Shamar.	Um Shomer derives its name from this plant.	Do.
204. do.	*Zozimia absinthifolia*, Vent.	Kalth.	Base of Asafia (East Sinai).	Hume Coll.
XXVI.—RUBIACEÆ.				
205. *Rubiaceæ.*	*Oldenlandia Schimperi*, (Presl.) Boiss.	....	Wadi Isla and Er Raha Plain.	Kneucker Coll.
206. do.	*Crucianella membranacea*, Boiss.	....	Lower Wadi Sheikh.	Do. P.F.
207. do.	*Crucianella ciliata*, Lam.	....	....	Post's Flora.
208. do.	Do. var. *hispidula*, Boiss.	....	Mount St Katharine.	Do.
209. do.	*Galium sinaicum*, (Decn.) Boiss.	....	Sinai Convent and Raha Plain in fissures of rock.	Kneucker Coll. P.F.
210. do.	*Galium tenerum*, Gaud.	....	Sides of Gebel Katharina 1850–1900 m.	Do. P.F.
211. do.	*Galium Decaisnei*, Boiss.	....	Rocks and shady places. Wadi Aleyat (Serbal).	Do. P.F.
212. do.	*Callipeltis cucullaria*, (L.) Boiss.	....	Raha Plain.	Do.
213. do.	*Callipeltis aperta*, Boiss. et Buhse.	....	....	Post's Flora.
XXVII.—DIPSACEÆ.				
214. *Dipsaceæ.*	*Scabiosa arenaria*, Forsk.	....	....	Do.
215. do.	*Scabiosa eremophila*, Boiss.	....	....	Do.
216. do.	*Pterocephalus sanctus*, Dan.	Samma.	....	Do.
XXVIII.—COMPOSITÆ.				
217. *Compositæ.*	*Erigeron Bovei*, (D.C.) Boiss.	Ghazani or [illegible]	Wadi Isla.	Kneucker Coll. P.F.

218.	do.	***Erigeron trilobum*, (Desn.) Boiss.**	**Nefleh or Qurad.**	**On rocks, Wadi Tarfa.**	**Do.**	P.F.
219.	do.	***Asteriscus pygmæus*, Coss. et Dur.**	....	Feiran Oasis and Maghara.	Do.	
220.	do.	*Asteriscus graveolens*, (Forsk.) Boiss.	Nimwar, &c.	Between Feiran and Maghara, and at Maghara.	Do.	P.F.
221.	do.	*Asteriscus Schimperi*, Boiss.	....	Sinai only.	Post's Flora.	
222.	do.	*Pulicaria undulata*, (L.) Boiss.	Rabboul.	Wadis Isla and Tarfa, Feiran Oasis.	Kneucker Coll.	O.S.
223.	do.	*Pulicaria Arabica*, Cass.	....	Feiran Oasis.	Do.	
224.	do.	*Pulicaria longifolia*, Boiss.	....	Moist places.	Post's Flora.	
225.	do.	*Filago spathulata*, var. *prostrata*, Boiss.	....	Sandy places.	Do.	
226.	do.	*Ifloga spicata*, Forsk.	Kureishat-el-Judai.	Near coast and sandy floor of valleys.	Hume Coll. K.C.	
227.	do.	*Phagnolon nitidum*, Fres.	Khananet-en na'gah.	Er Raha Plain and Wadi Aleyat.	Kneucker Coll.	
228.	do.	*Leyssera capillifolia*, Willd.	Oreib.	Common.	Do.	O.S.
229.	do.	*Inula glutinosa*, D.C.	....	....	Ord. Surv. Coll.	
230.	do.	*Iphiona juniperifolia*, Cass.	Oshbeh.	....	Do.	
231.	do.	*Iphiona scabra*.	Dafara.	Characteristic East Sinai Plant.	Hume Coll.	K.C.
232.	do.	*Varthemia montana*, Vahl.	Huneidah.	Rocky soil, base of Sinai.	Post's Flora.	
233.	do.	*Francœuria crispa*, Forsk.	Qutqat and many others.	Dry sandy soil, as dithdath at Mount Sinai.	Schweinfurth Coll.	
234.	do.	*Gymnarrhena micrantha*, Desf.	....	Sandy places.	Post's Flora.	
235.	do.	*Anvillœa Garcini*, Burm.	....	....	Do.	
236.	do.	*Achillea fragrantissima*, Forsk.	Qaisun.	....	Do.	
237.	do.	*Lasiopogon muscoides*, (Desf.) Boiss.	....	Sandy valley beds in small plants.	Kneucker Coll.	
238.	do.	*Gnaphalium pulvinatum*, Del.	....	Between Wadi Feiran and Maghara.	Do.	
239.	do.	*Anthemis deserti*, Boiss.	....	Lower Wadi Sheikh.	Do.	
240.	do.	*Anthemis melampodina*, Del.	Erbayan.	Nubian Sandstone plains.	Hume Coll.	
241.	do.	*Anthemis Kahirica*, Visiani.	....	Convent of St Katharina.	Post's Flora.	
242.	do.	*Anthemis rotata*, Boiss.	....	....	Do.	
243.	do.	*Chrysanthemum coronarium*, L.	....	Valley of Rephidim.	Do.	
244.	do.	*Pyrethrum santolinoides*, D.C.	Myrr.	Abundant on Sinai and other peaks.	Hume Coll.	K.C.
245.	do.	*Brocchia cinerea*, (Del.) Boiss.	Afrach., &c.	Abundant, especially in bed of valleys.	Kneucker Coll.	P.F.
246.	do.	*Artemisia herba-alba*, var. *laxiflora*, Boiss.	Shih.	The *densiflora* variety ghoreyra at Mount Sinai.	Do.	Schweinf. Coll.

List of Plants noted in the Sinai Peninsula—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XXVIII.—Compositæ, (*continued*).				
247. *Compositæ.*	*Artemisia Judaica*, L.	Betheran.	Ubiquitous.	Hume Coll., &c.
248. do.	*Artemisia monosperma*, Del.	'Adah.	....	Post's Flora.
249. do.	*Senecio Decaisnei*, var. *subsimplex*, Bornm.	Mururah, etc.	Rocks and sandy places frequent.	Kneucker Coll. P.F.
250. do.	*Senecio coronopifolius*, Desf.	Jerjir, etc.	....	Barron Coll. K.C.
251. do.	*Senecio flavus*, Schz.	Wein.	Common in south.	Hume Coll.
252. do.	*Calendula palestina*, Boiss.	Kahleh.	....	Barron Coll.
253. do.	*Calendula arvensis*, L.	....	....	Ord. Surv. Coll.
254. do.	*Tripteris Vaillanti*, Dec.	....	Sinai only.	Post's Flora.
255. do.	*Echinops glaberrimus*, D.C.	Khashir.	Abundant in mountains.	Hume Coll.
256. do.	*Atractylis flava*, Desf.	Akersh or Khosheruf.	Wadi Werdan.	Kneucker Coll. P.F.
257. do.	Do. var. *glabrescens*, Boiss.	....	W. Aleyat (Serbal) 650-750 m.	Do.
258. do.	*Carduus tenuiflorus*, L.	Khudan.	....	Ord. Surv. Coll.
259. do.	*Onopordon arabicum*, L.	....	....	Do.
260. do.	*Onopordon ambiguum*, Fres.	....	Waste places.	Post's Flora.
261. do.	*Amberboa Lippii*, L.	....	Sandy places.	Do.
262. do.	*Amberboa crupinoides*, Desf.	....	Wadi Berra.	Barron Coll.
263. do.	*Centaurea* sp. near *C. Postii*, Boiss.	....	Wadi Tarfa.	Kneucker Coll.
264. do.	*Centaurea araneosa*, Boiss.	....	Wadi Aleyat (Serbal).	Do.
265. do.	*Centaurea eryngoides*, Lam.	....	....	Ord. Surv. Coll.
266. do.	*Centaurea sinaica* D.C.	....	....	Post's Flora.
267. do.	*Centaurea ægyptiaca* L.	Marur.	....	Ord. Surv. Coll.
268. do.	*Zoeged purpurea*, Fres.	....	Wadi Aleyat.	Kneucker Coll.
269. do.	*Carduncellus eriocephalus*, Boiss.	....	Wadi Werdan.	Do.
270. do.	*Phæopappus scoparia*, Sieb.	....	....	Ord. Surv. Coll.
271. do.	*Koelpinia linearis*, Pall.	....	Debbet er Ramloh, Wadi El Sheikh, etc.	Barron Coll. K.C.
272. do.	*Picris cyanocarpa*, Boiss.	Numwerta-el-Hadan.	Valleys of Sinai.	Hume Coll. K.C.
273. do.	*Picris sulphurea*, Del.	....	....	Post's Flora.
274. do.	*Leontodon hispidum*, L.	Khozan.	....	Ord. Surv. Coll.
275. do.	*Lactuca undulata*, Ledeb.	....	El Bustan, foot of Sinai.	Post's Flora.

276.	do.	*Lactuca scariola*, L.	....	....	Do.
277.	do.	*Lactuca orientalis*, Boiss.	Yakhiss.	....	Schweinfurth Coll.
278.	do.	*Urospermum picroides*, (L.) Boiss.	....	Wadi Tarfa.	Kneucker Coll.
279.	do.	*Scorzonera mollis*, M.B. var. *gabrata*, Bornm.	....	Near summit of Gebel Katharina 2450 m.	Do.
280.	do.	*Scorzonera Schweinfurthi.*	....	Wadi el-Akhdar.	Barron Coll.
281.	do.	*Zollikoferia Arabica*, Boiss.	Haudhan, etc.	Between Wadis Werdan and Gharandel.	Kneucker Coll. P.F.
282.	do.	*Zollikoferia nudicaulis*, (L).	....	Ubiquitous.	Hume Coll. K.C.
283.	do.	*Zollikoferia glomerata*, (Cass.) Boiss.	Halawat-el-Ghazlan.	Between Wadis Maghara and Shellal.	Kneucker Coll. P.F.
284.	do.	*Zollikoferia spinosa*, Forsk.	Kebad.	Ubiquitous.	Hume Coll. K.C.
285.	do.	*Zollikoferia mucronata*, Forsk.	....	....	Post's Flora.
286.	do.	*Zollikoferia fallax*, Jaub. et Sp.	Marurah or Huwwah.	....	Do.
287.	do.	*Picridium Orientale*, D.C.	....	Widely distributed.	Kneucker Coll.
288.	do.	*Picridium tingitanum*, L.	Elbeden, etc.	....	Ord. Surv. Coll.
289.	do.	*Picridium* do. var. *minor*, Boiss.	....	....	Post's Flora.
XXIX.—CAMPANULACEÆ.					
290.	*Campanulaceæ.*	*Campanula dulcis*, Den.	....	Rocky slopes.	Do.
XXX.—SALVADORACEÆ.					
291.	*Salvadoraceæ.*	*Salvadora persica*, Garcin.	Arrak.	Coast of Gulf of Akaba.	Hume Coll.
XXXI.—ASCLEPIADEÆ.					
292.	*Asclepiadeæ.*	*Solenostemma arjel*, Hayne.	Arjel.	....	Ord. Surv. Coll.
293.	do.	*Gomphocarpus fruticosus*, R. Br.	do.	....	Do.
294.	do.	*Gomphocarpus sinaicus*, Boiss.	do.	In many mountain valleys.	Hume Coll. K.C.
295.	do.	*Calotropis procera*, (Willd), R.Br.	....	Especially in eastern valleys.	Do. K.C.
296.	do.	*Dæmia cordata*, R.Br.=*D. tomentosa*, Vatke.	Lebben-el-Hamarah.	....	Ord. Surv. Coll.
297.	do.	*Leptadenia pyrotechnica*, Forsk.	Markh.	Southern Sinai.	Hume Coll.
298.	do.	*Boucerosia sinaica*, Den.	....	....	Post's Flora.
XXXII.—BORRAGINEÆ.					
299.	*Borragineæ.*	*Heliotropium luteum*, Poir.	Hismah, etc.	Sandy places.	Post's Flora.
300.	do.	*Heliotropium Arbainense*, Fres.	Rahah or Qurfeh.	Wadi Berra, Wadis Isla and Tarfa.	Barron Coll. Kneucker Coll.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

National Order.	Plant.	Arabic Name.	Distribution.	Collection.
XXXVII.—BORRAGINEÆ. (*continued*).				
301. *Borragineæ*	*Heliotropium undulatum*, Vahl.	Libit.	Sandy places, fairly distributed.	Kneucker Coll. O.S.
302. do.	*Heliotropium persicum*, Lam.	....	Lower Wadi Sheikh.	Do.
303. do.	*Anchusa ægyptiaca*, (L.) D.C.	....	Wadi Tarfa, Wadi el Sheikh, Feiran Oasis.	Do.
304. do.	*Anchusa aggregata*, Lehm.	Temaliq or Qiri.	....	Post's Flora.
305. do.	*Anchusa hispida*, Forsk.	....	....	Do.
306. do.	*Anchusa Milleri*, Willd.	Kahali.	....	Barron and Hume Coll.
307. do.	*Trichodesma Africanum*. (L.) R. Br.	Haminah.	Widely distributed.	Kneucker Coll. O.S.
308. do.	*Trichodesma* do. var. *Ehrenbergii*, Post.	....	Sinai only.	Post's Flora.
309. do.	*Paracaryum micranthum*, Boiss.	Suleisileh.	Widely distributed.	Kneucker Coll. P.F.
310. do.	*Paracaryum rugulosum*, D.C.	Um Libbeid.	Er Raha Plain, at the Convent and Wadi Seba'iaa.	Do. P.F.
311. do.	*Echinospermum spinocarpum*, (Forsk.) Boiss.	....	Similar to above.	Do. P.F.
312. do.	*Echinospermum sinaicum*, D.C.	....	Sandy places.	Post's Flora.
313. do.	*Echiochilon fruticosum*.	Mugheira or Kahhaleh.	....	Do.
314. do.	*Alkanna orientalis*, (L.) Boiss.	Libit.	Wadi Isla, Tarfa, etc.	Kneucker Coll. P.F.
315. do.	*Myosotis hispida*, Schlect.	Lisan-eth-Thaur.	Hillsides.	Post's Flora.
316. do.	*Arnebia decumbens*, (Vent.).	....	Wadi el Sheikh.	Kneucker Coll.
317. do.	*Arnebia hispidissima*, Spreng.	Attahn.	....	Post's Flora.
318. do.	*Arnebia linearifolia*, D.C.	Kahali, etc. Awaynet-el-mousleman.	Sands.	Barron Coll. Schweinfurth Coll.
319. do.	*Arnebia tinctoria*, Forsk.	Shojarat-el-Anab.	....	Post's Flora.
320. do.	*Lithospermum callosum*, Sibth. et Sm.	....	Widely distributed.	Kneucker Coll.
321. do.	*Echium sericeum*, Vahl.	Saq-el-Hamam or Lisan-el-Asal.	Sandy places.	Post's Flora.
322. do.	*Echium longifolium*, Del.	....	....	Do.
323. do.	*Echium Rauwolfii*, Boiss.	Keheila, etc.	....	Do.

XXXIII.—GENTIANACEÆ.					
324. *Gentianaceæ.*	***Erythræa ramosissima*, Pers.**	....	**Feiran.**	**Kneucker Coll.**	
XXXIV.—CONVOLVULACEÆ.					
335. *Convolvulaceæ.*	*Convolvulus hystrix*, Vahl.	Shibrim.	Wadis Gnai and Hebran.	Hume Coll.	
326. do.	*Convolvulus lanatus*, Vahl.	Barhaimah or Rehamah.	Desert between Wadi Werdan and Suez.	Barron Coll.	K.C.
327. do.	*Convolvulus Schimperi*, Boiss.	....	Between Feiran Oasis and Maghara, also Gharandel and Werdan.	Kneucker Coll.	
328. do.	*Cuscuta brevistyla*, A. Braun.	....	....	Post's Flora.	
329. do.	*Cuscuta arabica*, Fres.	....	....	Do.	
XXXV.—SOLANACEÆ.					
330. *Solanaceæ.*	*Solanum nigrum*, L.	Anab-ed Dib.	Wadi Tarfa.	Kneucker Coll.	O.S.
331. do.	*Solanum sinaicum*, Vahl.	....	Sinai only.	Post's Flora.	
332. do.	*Solanum retroflexum.*	Anab-ed Dib.	Wadi Emlaha.	Hume Coll. Barron Coll.	
333. do.	*Withania somnifera*, L.	Sharmah and many others.	....	Ord. Surv. Coll.	
334. do.	*Lycium arabicum*, Schweinf.	....	Wadi Sa'al, etc.	Hume Coll.	K.C.
335. do.	*Hyoscyamus muticus*, L.	Sakran.	Ubiquitous.	Do.	K.C.
336. do.	*Hyoscyamus pusillus*, L.	Sufeira.	In hilly parts.	Kneucker Coll.	P.F.
337. do.	*Hyoscyamus albus*, var. *repandus*, Post.	Seikeran.	....	Post's Flora.	
338. do.	*Hyoscyamus boveana*, Dun.	Do.	Near Wadi Aad.	Hume Coll.	
XXXVI.-SCROPHULARIACEÆ.					
339. *Scrophulariaceæ.*	*Verbascum sinaiticum*, Benth.	Reira.	Sides of Mt Sinai.	Do.	K.C.
340. do.	*Verbascum Schimperianum*, Boiss.	....	....	Post's Flora.	
341. do.	*Celsia parviflora*, Dec.	Nefleh.	....	Do.	
342. do.	*Linaria ægyptiaca*, (L) Dun.	D'hami and many others.	Wadi Isla to Gebel Serbal.	Kneucker Coll.	O.S.
343. do.	*Linaria simplex*, D.C.	....	Wadi Tarfa and Er Raha Plain.	Do.	
344. do.	*Linaria macilenta*, Sec.	Halaweh.	....	Ord. Surv. Coll.	
345. do.	*Linaria hælava*, Forsk.	Nimwar. etc.	Wadi Sigg.	Barron Coll.	
346. do.	*Linaria ascalonica*, Boiss at Ky.	....	....	Post's Flora.	
347. do.	*Linaria spuria*, Willd.	....	....	Ord. Surv. Coll.	
348. do.	*Anarrhinum pubescens*, Fres.	Arphaiji.	Rocks, base of Sinai.	Post's Flora.	

LIST OF PLANTS NOTED IN THE SINAI PENINSULA.—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XXXVI.-SCROPHULARIACEÆ (*continued*).				
349. *Scrophulariaceæ.*	*Antirrhinum orontium*, L.	Saisam.	....	Post's Flora.
350. do.	*Scrophularia xanthoglossa*, Boiss. β. *decipiens*, Boiss.	....	Foot of Ras Safsaf.	Kneucker Coll.
351. do.	*Scrophularia libanotica*, Boiss.	....	Summit of Gebel Katharina 2600 metres.	Do.
352. do.	*Scrophularia deserti*, Del.	Zeiteh.	El Bustan, Sinai.	Post's Flora.
353. do.	*Scrophularia* aff. *Kotschyi*, Boiss.	....	....	Ord. Surv. Coll.
354. do.	*Lindenbergia sinaica*, (Dcsn.) Benth.	....	Wadis Isla and Tarfa.	Kneucker Coll. P.F.
355. do.	*Veronica anagallis*, L.	....	Moist places in Wadi Tarfa.	Do. O.S.
356. do.	*Veronica macropoda*, Boiss.	....	Near summit of Gebel Katharina, 2000-2500 metres.	Do.
357. do.	*Veronica beccabunga*, L.	....	Wet places.	Ord. Surv. Coll.
XXXVII.—OROBANCHACEÆ.				
358. *Orobanchaceæ.*	*Cistanche tubulosa*, Wight.	....	Parasitic on tamarisk.	Kneucker Coll.
359. do.	*Phelipæa tubulosa*, Schenk.	Therthur.	Do.	Post's Flora.
XXXVIII.—ACANTHACEÆ.				
360. *Acanthaceæ.*	*Blepharis edulis*, (Forsk). Pers.	Shank-ed-Dibb.	Between Feiran Oasis and foot of Serbal.	Kneucker Coll. P.F.
XXXIX.—GLOBULARIEÆ.				
361. *Globularieæ.*	*Globularia arabica*, Jaub.	....	Near top of Serbal ab. 1900 m.	Do. O.S.
XL.—VERBENACEÆ.				
362. *Verbenaceæ.*	*Avicennia officinalis*, L.	Shora.	Growing on shores of Gulf of Akaba.	Hume Coll.
XLI.—LABIATÆ.				
363. *Labiateæ.*	*Lavandula coronopifolia*, Poir.	Zeiteh.	Southern Sinai.	Do.
364. do.	*Lavandula pubescens*, Dec.	....	....	Post's Flora.
365. do.	*Mentha sylvestris*, var. *angustifolia*.	Hublak.	Ain Shiddik.	Barron Coll.
366. do.	*Mentha tomentosa*, d'Urv.	....	....	Ord. Surv. Coll.
367. do.	*Origanum maru*, L. β. *Sinaicum*, Boiss.	Za'tar.	Gebel 'Arribe (1700 m.) and between Feiran Oasis and [illegible]	Kneucker Coll. P.F.

368.	do.	*Origanum nervosum*, Vog.	....	....	Ord. Surv. Coll.	
369.	do.	*Thymus decussatus*, Bth.	Zateran.	....	Do.	
370.	do.	*Micromeria sinaica*, Bth.	Suleisileh.	Between Feiran Oasis and Serbal.	Kneucker Coll.	P.F.
371.	do.	*Micromeria* sp.	....	On Gebel Musa, 1900-2000 m.	Do.	
372.	do.	*Salvia spinosa*, L.	....	Wadis Isla and Tarfa.	Do.	
373.	do.	*Salvia lanigera*, Poir.—*S. controversa*, Ten.	Nu'eimeh.	Sandy places Wadi El Sheikh.	Do.	P.F.
374.	do.	*Salvia ægyptiaca*, L.	Ra'al or Shajarat-el-Ghazal.	Between Feiran Oasis and Serbal.	Do.	P.F.
375.	do.	*Salvia deserti*, Dec.	Ghubeish or Shehibi.	Hilly parts.	Do.	P.F.
376.	do.	*Nepeta septemcrenata*, Ehrenb.	....	Wadi Tarfa.	Do.	P.F.
377.	do.	*Stachys affinis*, Fres.	Girtob.	Widely distributed.	Do.	O.S.
378.	do.	*Ballota undulata*, Bth.	Owseh or rassah.	....	Ord. Surv. Coll.	
379.	do.	*Otostegia Schimperi*, Bth.	Ghassah.	Large bush in South Sinai.	Hume Coll.	
380.	do.	*Otostegia mollucoides*, (Vahl.) Jaub. et Sp.	....	Wadi Isla.	Kneucker Coll.	P.F.
381.	do.	*Phlomis aurea*, Desn.	....	Gebel Arribe.	Do.	P.F.
382.	do.	*Phlomis angustifolia*, β. *flavescens*.	Awarwar.	....	Ord. Surv. Coll.	
383.	do.	*Ajuga tridactylites*, Gingins.	....	Near summits of Gebel Musa and Katharina.	Kneucker Coll.	
384.	do.	*Teucrium polium*, L.	Ja'adeh.	Between Feiran Oasis and Serbal.	Do.	O.S.
385.	do.	*Teucrium leucocladum*, Boiss.	Do.	Rocks: Wadi Hebran.	Post's Flora.	
386.	do.	*Teucrium sinaicum*, Boiss.	Do.	Rocks.	Schweinfurth Coll.	
XLII.—PLANTAGINEÆ.						
387.	*Plantagineæ*.	*Plantago cylindrica*, Forsk.	Um Labbeideh or Barkhemy.	Widely distributed.	Kneucker Coll.	O.S.
388.	do.	*Plantago amplexicaulis*, Cav.	....	Wadi Isla.	Do.	
389.	do.	*Plantago ovata*, Forsk.	....	Feiran Oasis and between it and Serbal.	Do.	
390.	do.	*Plantago ciliata*, Desf.	....	Wadi Shellal.	Do.	P.F.
391.	do.	*Plantago arabica*, Boiss.	Hashir.	Gebel Arribe, about 1750 m.	Do.	O.S.
392.	do.	*Plantago psyllium*, L.	....	Fairly common.	Do.	
393.	do.	*Plantago phæostoma*, Boiss. et Held.	....	Sands.	Post's Flora.	

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—*(continued)*.

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XLIII.—NYCTAGINEÆ.				
394. *Nyctagineæ.*	*Boerhaavia plumbaginea,* var. *dichotoma* (Vahl).	Duweinat el Far.	Wadis Isla and Tarfa.	Kneucker Coll.
395. do.	*Boerhaavia* do., var. *glabrata.*	Do.	....	Post's Flora.
396. do.	*Boerhaavia* do., var. *viscosa.*	....	....	Do.
397. do.	*Boerhaavia verticillata,* Poir.	....	....	Ord. Surv. Coll.
XLIV.—AMARANTACEÆ.				
398. *Amarantaceæ.*	*Aerua javanica,* Juss.	Ara.	Wide distribution in Eastern Sinai.	Hume Coll. K.C.
XIV.—CHENOPODIACEÆ.				
399. *Chenopodiaceæ.*	*Chenopodium murale,* L.	Fiss-el-Kilab and many others.	Wadi Gharandel.	Kneucker Coll. P.F.
400. do.	*Atriplex dimorphostegium* Kar. et Kir.	....	Feiran Oasis and Wadi Gharandel.	Do.
401. do.	*Atriplex* aff. *roseum,* L.	....	....	Ord. Surv. Coll.
402. do.	*Atriplex leucocladum,* Boiss.	Rudhl, etc.	....	Post's Flora.
403. do.	*Atriplex farinosum,* Forsk.	Huway or Asfay.	Gebel Naqus.	Do.
404. do.	*Kochia muricata,* (L). Schrad.	Layyah.	Widely distributed.	Kneucker Coll. P.F.
405. do.	*Kochia latifolia,* Fres.	....	Wadis Isla, Tarfa and El Sheikh.	Do. P.F.
406. do.	*Kochia* do., var. *inermis,* Boiss.	....	....	Post's Flora.
407. do.	*Halocnemum strobilaceum,* Pall.	Sabteh.	On coast.	Do.
408. do.	*Arthrocnemum glaucum,* Del.	Ushnan.	Salt marshes, Tor.	Do.
409. do.	*Sueda* vermiculata,* Forsk.	Suweid.	In Gulf of Suez near Ras Abu Zenima.	Kneucker Coll. P.F.
410. do.	*Sueda fruticosa,* L.	Malih.	....	Ord. Surv. Coll.
411. do.	*Suæda monoica,* Forsk.	Asal.	At El Noweiba, etc.	Post's Flora.
412. do.	*Shanginia baccata,* Forsk.	Tartir, etc.	....	Do.
413. do.	*Traganum nudatum,* Del.	Feres, etc.	....	Do.
414. do.	*Haloxylon articulatum,* Cav.	Belbel.	....	Do.
415. do.	*Haloxylon Schweinfurthii,* Aschers.	Rimth.	North of and in Wadi Nasb.	Hume Coll.
416. do.	*Salsola kali,* L.	....	Qa'a Plain.	Kneucker Coll.

420.	do.	*Salsola* ctr. *S. longifolia*, Forsk.	Hampl.	....	Ord. Surv. Coll.	
421.	do.	*Anabasis articulata* (Forsk), Moq.	Ajram.	Widely distributed e. g. Senned plain.	Do.	
422.	do.	*Anabasis setifera*, Moq.	Hamr.	Typical mountain plant.	Hume Coll.	
XLVI.—POLYGONACEÆ.						
423.	*Polygonaceæ.*	*Calligonum comosum*, Lher.	Arta.	Wadi Kyd, etc.	Do.	
424.	do.	*Rumex vesicarius*, L.	Hamatha.	Frequent.	Do.	
425.	do.	*Atraphaxis spinosa*, L. var. *sinaica* (Jaub. et Sp.) Boiss.	Suweid.	Jebel Arribe, 1750 m.	Kneucker Coll.	O.S.
XLVII.—EUPHORBIACEÆ.						
426.	*Euphorbiaceæ.*	*Euphorbia cornuta*, Pers.	Libeineh.	Er Raha Plain and Wadi el Sheikh.	Do.	O.S.
427.	do.	*Euphorbia chamæpeplus*, var. *sinaica*, Boiss. et Gaill.	....	Er Raha Plain.	Do.	P.F.
428.	do.	*Euphorbia oborata*, Dcn.	Libeineh.	Betwein Wadi Rahabeh and Wadi Rutig.	Do.	O.S.
429.	do.	*Euphorbia peplis*, L.	....	....	Ord. Surv. Coll.	
430.	do.	*Euphorbia terracina*, L. var. *prostrata*, Boiss.	....	....	Post's Flora.	
431.	do.	*Andrachne telephioides*, L.	Libbaneh.	Er Raha Plain.	Kneucker Coll.	P.F.
432.	do.	*Andrachne aspera*, Spreng.	Kimmash.	....	Post's Flora.	
433.	do.	*Crozophora tinctoria*, L.	Yera.	....	Ord. Surv. Coll.	
434.	do.	*Crozophora obliqua*, Vahl.	Sammah.	....	Post's Flora.	
XLVIII.—URTICACEÆ.						
435.	*Urticaceæ.*	*Parietaria alsinæfolia*, Del.	Sh'lit, etc.	Wadis Tarfa and El Sheikh, also near foot of Serbal.	Kneucker Coll.	P.F.
436.	do.	*Forskahlea tenacissima*, L.	Lissaq.	Wadis Isla and Tarfa.	Do.	O.S.
437.	do.	*Ficus pseudo-sycamorus*, Dcn.	Zamyuk, etc.	....	Ord. Surv. Coll.	
438.	do.	*Ficus carica*, L. γ. *rupestris*, Hausskn.	....	Upper part Wadi Tarfa and on Serbal, at 1900m.	Kneucker Coll.	
XLIX.—SALICINEÆ.						
439.	*Salicineæ.*	*Salix octandra*, Sieb.	Safsafeh.	....	Ord. Surv. Coll.	
L.—PALMÆ.						
440.	*Palmæ.*	*Phœnix dactylifera*, L.	Nakhl.	Many palm-groves.	....	
441.	do,	*Hyphæne thebaica*, Gaertn.	Dom.	Near Tor.	Post's Flora.	

* Three species of *Suæda* not more closely determined recorded by Kneucker.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—*(continued)*.

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
LI.—COLCHICACEÆ.				
442. *Colchicaceæ.*	*Colchicum fasciculare*, L.	Baisur.	....	Post's Flora.
443. do.	*Colchicum Ritchii*, R. Br.	....	....	Do.
444. do.	*Colchicum Steveni*, Kunth.	....	Gebel Katharina.	Do.
445. do.	*Colchicum velutinum*, Born. et Kneucker.	....	Summit of Gebel Katharina above 2450 m.	Kneucker Coll.
446. do.	*Colchicum bulbocodoides*, Brot.	....	....	Ord. Surv. Coll.
LII.—HYDROCHARITACEÆ.				
447. *Hydrocharitaceæ.*	*Halophila stipulacea*, Forsk.	....	On Red Sea.	Post's Flora.
LIII.—ASPARAGACEÆ.				
448. *Asparagaceæ.*	*Asparagus horridus*, L.	....	....	Ord. Surv. Coll.
LIV.—LILIACEÆ.				
449. *Liliaceæ.*	*Asphodelus fistulosus*, L.	Barwal.	....	Do.
450. do.	*Asphodelus tenuifolius*, Cav. β. *micranthus*, Boiss.	Borwaq.	Common.	Hume Coll. K.C.
451. do.	*Allium sinaiticum*, Boiss.	Buttait.	....	Post's Flora.
452. do.	*Allium staminium*, Boiss.	....	Summit of Gebel Katharina.	Do.
453. do.	*Dipcadi erythræum*, Webb.	Bureiyit, etc.	....	Do.
454. do.	*Bellevalia*, sp.	....	....	Barron Coll.
455. do.	*Gagea reticulata*, Pall. β. *tenuifolia*, Boiss.	....	Near Summit of Gebel Katharina.	Kneucker Coll. P.F.
LV.—JUNCACEÆ.				
456. *Juncaceæ.*	*Juncus effusus* L.	Saumar or Bardi.	Wet places.	Post's Flora.
457. do.	*Juncus punctorius*, L.	....	....	Do.
458. do.	*Juncus maritimus*, var. *arabicus*, Asch. et Buch.	Sammar.	....	Buchenau autor.
459. do.	*Juncus bufonius* L. f. *fasciculiflora.*	....	Moist places in Feiran Oasis.	Kneucker Coll.
460. do.	*Juncus* do., var. *subauriculata*, Buchenau.	....	Do.	Do.
LVI.—NAIADACEÆ.				
461. *Naiadaceæ.*	*Ruppia rostellatus*, Koch.	Henzislud.	Near Tor.	Post's Flora.
462. do.	*Cymodocea rotundata*, Ehr. and Hemp.	....	Tor.	Do.

				Zenima and W. Gharandel.		
468.	do.	*Holoschœnus australis*,(L.)Fritsch	....	Wadi Tarfa and Feiran Oasis.	Do.	
469.	do.	*Scirpus holoschœnus*, L.	Diss.	....	Ord. Surv. Coll.	
LVIII.—GRAMINEÆ.						
470.	*Gramineæ.*	*Tricholæna Teneriffæ* (L.) Parl.	....	Lower Wadi Isla, Wadi Tarfa and Aleyat.	Kneucker Coll.	
471.	do.	*Panicum turgidum*, Forsk.	Theman.	Common in East Sinai.	Hume Coll., etc.	
472.	do.	*Pennisetum dichotomum*, (Forsk.) Del.	....	Between Feiran Oasis and Maghara.	Kneucker Coll.	
473.	do.	*Pennisetum elatum*, Hochst.	....	Near Naqb.	Post's Flora.	
474.	do.	*Pennisetum ciliare*, L.	....	....	Do.	
475.	do.	*Pennisetum sinaicum*, Dcn.	Sabot.	....	Ord. Surv. Coll.	
476.	do.	*Pennisetum cenchroides*.	....	Wadi Hebran.	Barron Coll.	
477.	do.	*Imperata cylindrica*, L.	....	....	Post's Flora.	
478.	do.	*Imperata arundinacea*, Cyr.	....	....	Ord. Surv. Coll.	
479.	do.	*Pollinia distachya*, L.	....	....	Post's Flora.	
480.	do.	*Andropogon hirtus*, L.	....	Lower Wadi Isla and Er Raha Plain.	Kneucker Coll.	
481.	do.	*Aristida cærulescens*, Desf.	....	Widely distributed.	Do.	P.F.
482.	do.	*Aristida ciliata*, Desf.	....	Wadi Um Agraf. In rocky and very sunny spots.	Barron Coll.	K.C.
483.	do.	*Aristida plumosa*, L.	Dhereri, etc.	Qa'a Plain.	Kneucker Coll.	
484.	do.	*Aristida coloptila*, (Jaub et Sp.) Boiss.	Nesi.	Widely distributed.	Do.	
485.	do.	*Aristida obtusa*, Del.	Dereri or Sefsuf.	....	Post's Flora.	
486.	do.	*Aristida brachypoda*, Tausch.	Sefsuf.	....	Do.	
487.	do.	*Aristida hirtiglumа*, Steud.	....	....	Do.	
488.	do.	*Stupa parviflora*, Desf.	....	Common in Sinai region.	Kneucker Coll.	P.F.
489.	do.	*Stupa tortilis*, Desf.	Sefsuf.	Common on granitic detritus near Sinai and Serbal.	Do.	
489*a*.	do.	*Stupa barbata*. Desf.	....	....	Post's Flora.	
490.	do.	*Tetrapogon villosus*, Desf.	....	On rocks in Wadi Tarfa, and at Sinai Convent.	Do.	P.F.
491.	do.	*Oryzopsis miliacea*, (L.), Coss. and Dur.	Zibl-Abu-Hoseyn.	Wadi Aleyat and Mount Sinai.	Post's Flora, Schweinfurth Coll.	
492.	do.	*Oryzopsis holciformis*, (M. B.) Hackel.	....	Near summit Gebel Katharine, 2450 m.	Kneucker Coll.	
493.	do.	*Agrostis verticillata*, Vill.	....	Feiran Oasis and Wadi Aleyat.	Do.	
494.	do.	*Polypogon monspeliense*,(L.) Desf	Dheib-eth-The'leb	In moist places.	Do.	O.S.

List of Plants noted in the Sinai Peninsula—(*continued*).

	Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.	
	LVIII.—GRAMINEÆ.—(*cont.*)					
495.	*Gramineæ.*	*Avena barbata*, Brot.	Khafur or Sheifun	Foot of Ras Safsaf.	Kneucker Coll.	O.S.
496.	do.	*Danthonia Forskâlei* (Vahl.) Trin.	....	Very common.	Do.	
497.	do.	*Cynodon dactylon*, L.	Néjil.	Feiran Oasis.	Do.	O.S.
498.	do.	*Setaria glauca*, P. de Beauv.	....	....	Ord. Surv. Coll.	
499.	do.	*Pappophorum brachystachyum*, Jaub et Sp.	....	Feiran Oasis.	Kneucker Coll.	
500.	do.	*Boissiera bromoides*, Hochst.	....	Between Wadi Tarfa and Sinai and Er Raha Plain.	Do.	P.F.
501.	do.	*Phragmites communis*, Trin. var. β. *Isaica*, Coss.	....	Bushes in Wadi Isla and Tarfa.	Do.	
502.	do.	*Lamarckia aurea*, (L.) Mœnch.	....	Wadi Aleyat.	Do.	
503.	do.	*Koeleria phleoides*, Vill.	....	Wadi el Sheikh, Er Raha Plain, and Feiran Oasis.	Do.	
504.	do.	*Koeleria sinaica*, Boiss.	....	....	Post's Flora.	
505.	do.	*Schismus calycinus*, (L.) Coss.	Behmeh or Safsuf.	Common in valleys.	Kneucker Coll.	P.F.
506.	do.	*Schismus arabicus*, Nees.	Abu-Machy.	Mount Sinai.	Schweinfurth Coll.	
507.	do.	*Poa sinaica*, Steud.	....	Summit of Gebel Katharina (2600m. and Er Raha Plain)	Kneucker Coll.	P.F.
508.	do.	*Vulpia inops*, Del.	....	....	Post's Flora.	
509.	do.	*Cutandia memphitica*, (Spreng.) Richter.	....	Feiran Oasis.	Kneucker Coll.	P.F.
510.	do.	*Bromus tectorum*, v. *anisantha*, Hackel.	....	Valleys near Sinai.	Do.	O.S.
511.	do.	*Bromus tectorum*, L. × *Japonicus*, Thunb.	....	Wadi Tarfa (ab. 1100m.).	Do.	
512.	do.	*Bromus flabellatus*, Hackel.	....	....	Post's Flora.	
513.	do.	*Bromus madritensis*, L. var. *Delilei*, Boiss.	....	Feiran Oasis.	Kneucker Coll.	P.F.
514.	do.	*Bromus maximus*, Desf.	....	Do.	Do.	
515.	do.	*Bromus rubens*, L.	....	Do. and Wadi Aleyat.	Do.	P.F.
516.	do.	*Bromus fasciculatus*, Presl.	....	Er Raha Plain and Lower Wadi el Sheikh.	Do.	
517.	do.	*Bromus Japonicus*. Thunb. v. *Sinaica*, Hackel.	2 varieties.	Wadis Tarfa and Isleh, Er Raha Plain and Wadi el	Do.	

			or Timzein.			
521.	do.	*Brachypodium distachyum*, (L.) R. et Sch.	....	Wadi Isla, Er Raha Plain, Maghara.	Kneucker Coll.	
522.	do.	*Triticum durum*, Desf. var. *megapolitana*, Kœm.	....	Feiran Oasis (planted).	Do.	
523.	do.	*Lolium rigidum*, Gaud.	....	Feiran Oasis.	Do.	
524.	do.	*Hordeum murinum*, L.	....	Do. Er Raha Plain and Gebel Arribe.	Do.	
	LIX.—CONIFERÆ.					
525.	*Coniferæ.*	*Cupressus semprevirens*, L.	....	Gebel Musa.	Do.	
	LX.—GNETACEÆ.					
526.	*Gnetaceæ.*	*Ephedra alata*, Decn. var. *Decaisnei*, Stapf.	Adam.	Common.	Do.	P.F.
527.	do.	*Ephedra* cfr. *E. fragilis*, L.	Aldi.	....	Ord. Surv. Coll.	

CRYPTOGAMÆ.

	PTERIDOPHYTA.					
528.	*Polypodiaceæ.*	*Adiantum capillus veneris*, L.	....	Near streams in Wadi Isla, Tarfa, etc.	Hume Coll. K.C.	
529.	do.	*Notochlæna lanuginosa*, Desf.	....	....	Ord. Surv. Coll.	
530.	do.	*Cheilanthus fragrans*, W and B.	Girai.	....	Do.	
531.	*Equisitaceæ.*	*Equisetum ramossissimum*, Desf. f. *Firanensis*, Luerssen.	. ..	Feiran Oasis.	Kneucker Coll.	
532.	do.	*Equisetum elongatum*, Willd.	Namos.	....	Ord. Surv. Coll.	
	BRYOPHYTA.					
533.	*Pottiaceæ.*	*Gyroweisia Mosis*, (Lor.) Par.	....	On Serbal on coarse granite 1500-1600 m.	Kneucker Coll.	
533*a*	do.	*Gyroweisia Aaronis*, (Lor.) Par.	....	....	Ehrenberg Coll.	
534.	do.	*Didymodon tophaceus*, (Brid.) Jur.	....	On G. Katharina 1900-2100 m. and Serbal, 1800 m.	Kneucker Coll.	
535.	do.	*Didymodon Ehrenbergii*, (Lor.) Kindb.	....	In brook, Wadi Tarfa.	Do.	
536.	do.	*Barbula gracilis*, (Schleich). Schwar var. β. *viridis*, Br. eur.	....	Serbal 1500-1900 m.	Do.	
537.	do.	*Barbula vinealis*, Brid.	....	On granite, Serbal, 1950 m.	Do.	
537*a*	do.	*Aloina aloides*, (Koch.) Kindb.	....	....	Ehrenberg Coll.	
538.	do.	*Crossidium Geheebii*, Broth.	....	On coarse granite, Serbal, 1800-1900 m.	Kneucker Coll.	

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Cryptogamæ—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
BRYOPHYTA.—(*cont.*).				
538*a* *Pottiaceæ*.	*Crossidium squamigerum*, Viv. (Jur.).	....	....	Ehrenberg Coll.
539. do.	*Tortula atrovirens*, (Sm.) Lindb.	....	Serbal, 1500-1900 m.	Kneucker Coll.
540. do.	*Tortula Kneuckeri*, Broth. and Geh.	....	Lower part of Gebel Katharina, 1900-2100 m.	Do.
541. do.	*Tortula rigescens*, Broth and Geh.	....	Gebel Katharina 1900 m. and Serbal 1800-1900 m.	Do.
541*a* do.	*Eucladium verticillatum*, L.	....	....	Ehrenberg Coll.
542. do.	*Encalypta intermedia*, Jur.	....	On Serbal, 1950 m.	Kneucker Coll.
543. *Grimmiaceæ*.	*Grimmia alpicola*, Sw.	....	Do.	Do.
544. do.	*Grimmia anodon*, Bryol. eur.	....	Gebel Arribe, 1700-1800 m. Gebel Katharina 2450, Serbal 1800-1900 m.	Do.
545. do.	*Grimmia sinaica*, Hpe.	....	Gebel Arribe, 1700-1800 m., Serbal 1800-1900 m.	Do.
546. *Bryaceæ*.	*Bryum capillare*, (L).	....	Serbal, 1950 m.	Do.
547. do.	*Bryum cæspiticium*, L.	....	G. Katharina, 1600-2100 m.	Do.
548. do.	*Bryum gemmiporum*, De Not.	....	G. Katharina, 1900-2100 m.	Do.
549. do.	*Bryum atropurpureum*, Whlbg.	....	Do. also G. Musa 1500-1700 m., G. Katharina 1900-2100 m.	Do.
550. do.	*Bryum syriacum*, Lor.	....	Small brook in Wadi Tarfa, 600-1050 m.	Do.
551. do.	*Bryum schleicheri*, Schwgr.	....	....	Schimper Coll.
552. *Hypnaceæ*.	*Brachythecium umbilicatum*, Jur. and Milde.	....	Serbal 1950 m.	Kneucker Coll.
553. do.	*Rhynchostegiella tenella*, Dicks.	....	....	Ehrenberg Coll.
554. do.	*Rhynchostegium rusciforme*, Neck	....	....	Do.
555. *Funariaceæ*.	*Entosthodon templetoni*, Neck.	....	....	Schimper Coll.
556. *Lichenes*.	*Gasparinia elegans*,(Lk.)Thornb.	....	Near summit of Serbal, 1950 m.	Kneucker Coll.
557. *Fungi*.	*Cystopus candidus*, (Pers.) Lév.	....	On *Diplotaxis harra* in Wadi El Sheikh.	Do.
558. *Characeæ*.	*Chara gymnophylla*, f. *subinermis*	....	Brook in Wadi Isla.	Do.

ALGAE.

	Natural Order.	Plant.	Distribution.	Collection.
559.	*Desmidiaceæ*.	*Mesotænium Kramstai*, var. *Kneuckeri*, Lemmer.	Er Raha Plain (1500 m.).	Kneucker Coll.
560.	do.	*Closterium Leibleinii*, Ktzg.	Wadis Tarfa and Isla.	Do.
561.	do.	*Cosmarium læve*, Rabh.	Very common.	Do.
562.	do.	*Cosmarium*, do. var. *septentrionalis*, Wille.	Gebel Serbal (1,500m.), Wadi Tarfa and Er Raha Plain.	Do.
563.	do.	*Cosmarium Meneghinii*, Breb.	Er Raha Plain (1500 m.).	Do.
564.	do.	*Cosmarium Naegelianum*, Breb. var. *crenulata*, Schmidle.	Wadi Tarfa.	Do.
565.	do.	*Cosmarium crenatum*, var. *nana*, Wittr.	Er Raha Plain.	Do.
566.	do.	*Cosmarium subcrenatum*, Hantsch.	Wadi Isla.	Do.
567.	do.	*Cosmarium subpunctulatum*, Nordst. f. *lævis*, Schmidle.	On Serbal (1500 m.), abundant.	Do.
568.	do.	*Cosmarium margaritiferum* (Turp), Menegh.	Wadi Isla.	Do.
569.	do.	*Cosmarium botrytis* (Bory), Menegh.	Wadi Tarfa.	Do.
570.	*Zygnemaceæ*.	*Zygnema stellinum* (Vench.), Ag.	Wadi Tarfa (rare).	Do.
571.	do.	*Spirogyra cateneformis* (Hass.), Ktzg.	Foot of Gebel Musa.	Do.
572.	*Pleurococcaceæ*.	*Rhaphidum polymorphum*, Fres. var. *falcata*, Rabh.	Sides of Gebel Katharina.	Do.
573.	do.	*Scenedesmus bijugatus* (Turp), Ktzg. var. *alternans*, Hsg.	Wadi Tarfa.	Do.
574.	do.	*Scenedesmus obliquus*, (Turp), Ktzg.	Wadi Isla.	Do.
575.	do.	*Oocystis solitaria*, Wittr.	Wadi Tarfa.	Do.
576.	*Hydrodictiaceæ*.	*Pediastrum integrum*, Naeg.	Do.	Do.
577.	*Ulotrichaceæ*.	*Ulotrix subtilis*, Ktzg., var. *stagnorum*.	On Gebel Katharina.	Do.
578.	*Oedogonaceæ*.	*Oedogonium cardiacum*, var. *carbonica*, Wittr.	Wadi Tarfa.	Do.
579.	do.	*Oedogonium rufescens*, var *Lundelli*, Wittr.	Do.	Do.
580.	do.	*Oedogonium Gunnii*, Wittr.	On Serbal.	Do.
581.	*Cladophoraceæ*.	*Cladophora fracta* (Walh.), Brand.	Wadi Isla.	Do.
582.	*Sphæropleaceæ*.	*Sphæropla Braunii*, Ktzg.	Er Raha Plain.	Do.
583.	*Chroococcaceæ*.	*Chroococcus turgidus*, (Ktzg.), Naeg.	Wadi Tarfa	Do.
584.	*Rivulariaceæ*.	*Calothrix parietina*, Thur.	Er Raha Plain.	Do.
585.	do.	*Gloeochotrichia Indica*, Schmidle.	Feiran Oasis.	Do.
586.	*Diatomaceæ*.	*Epithemia gibba*.	Common	Fraas and Ord. Surv. Coll.
587.	do.	*Epithemia argus*.	Ayun Musa, Wadi Tarfa and Um Shomer.	Fraas and Drake Coll.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Distribution.	Collection.
	Algae—(*continued*).		
588. *Diatomaceæ.*	*Epithemia rupestris.*	Wadis Gharba, Zawatin, Gharandel and Bab'a.	Ord. Surv. Coll.
589. do.	*Epithemia turgida.*	Wadis Zawatin, Aleyat, and Hebran.	Do.
590. do.	*Epithemia alpestris.*	Wadi Zawatin.	Do.
591. do.	*Epithemia sorex.*	Wadi Hebran.	Do.
	DIATOMACEÆ.		
592. do.	*Surirella ovalis.*	Ayun Musa and Wadi Gharandel.	Drake and Wilson Coll.
593. do.	*Surrirella ovata.*	AyunMusa=Moses wells,near Suez.	Do.
594. do.	*Surirella pinnata.*	Do.	Drake Coll.
595. do.	*Surirella linearis*, var. *constricta.*	Wadi Bab'a.	Ord. Surv. Coll.
596. do.	*Cyclotella Kützingiana.*	Ayun Musa and Tor.	Wilson Coll., Haig Coll.
597. do.	*Cymbella (? scotica).*	Wadi Sigilliya.	Ord. Surv. Coll.
598. do.	*Amphora minutissima.*	Wadi Zawatin.	Do.
599. do.	*Cocconeis placentula.*	Ayun Musa, Wadi Aleyat, Gebel Musa and Wadi Hebran.	Ord. Surv. Coll. and Wilson Coll.
600. do.	*Cymatopleura solea.*	Ayun Musa.	Wilson Coll.
601. do.	*Campylodiscus bicostatus.*	Tor.	Haig Coll.
602. do.	*Nitzschia sigma.*	Ayun Musa.	Drake Coll.
603. do.	*Nitzschia linearis.*	Wadis Gharba, Zawatin, Er Rimm and Sigilliya.	Ord. Surv. Coll.
604. do.	*Nitzchia amphioxys.*	Wadi Zawatin.	Do.
605. do.	*Nitzschia minutissima.*	Do.	Do.
606. do.	*Nitzschia dubia.*	Do.	Do.
607. do.	*Pleurosigma lacustre.*	Ayun Musa.	Wilson Coll.
608. do.	*Pleurosigma delicatulum.*	Ayun Musa and Tor.	Wilson Coll., Haig Coll.
609. do.	*Pleurosigma attenuatum.*	Ayun Musa.	Drake Coll.
610. do.	*Stauroneis achnanthes.*	Wadi Gharbeh.	Ord. Surv. Coll.
611. do.	*Stauroneis dilatata.*	Wadi Zawatin.	Do.
612. do.	*Navicula elliptica.*	Wadis Gharba, Zawatin and Er Rimm.	Do.
613. do.	*Navicula rhyncocephala.*	Ayun Musa and Wadi Zawatin.	Ord. Surv. Coll. and Wilson Coll.

615.	do.	*Navicula ovalis.*	Do.	Drake Coll.
616.	do.	*Navicula ambigua.*	Wadi Zawatin.	Ord. Surv. Coll.
617.	do.	*Navicula lævissima.*	Do.	Do.
618.	do.	*Navicula mesostyla* (?).	Do.	Do.
619.	do.	*Pinnularia viridula.*	Ayun Musa.	Drake Coll.
620.	do.	*Pinnularia viridis.*	Ayun Musa, Wadi Zawatin and Um Shomer.	Fraas Coll. and Ord. Surv. Coll.
621.	do.	*Pinnularia acrosphæria.*	Wadi Gharba.	Ord. Surv. Coll.
622.	do.	*Pinnularia oblonga.*	Wadi Zawatin.	Do.
633.	do.	*Pinnularia acuta.*	Do.	Do.
624.	do.	*Pinnularia radiosa*, var. *acuta.*	Wadi Sigilliya.	Do.
625.	do.	*Synedra fasciculata.*	Ayun Musa.	Drake Coll.
626.	do.	*Synedra fragilis?*	Do.	Wilson Coll.
627.	do.	*Synedra familiaris.*	Do.	Do.
628.	do.	*Synedra radiosa.*	Gebel Musa, Wadis Tarfa, Hebran and Sigilliya.	Ord. Surv. Coll.
629.	do.	*Synedra amphirhyncus* (?)	Wadi Er Rimm.	Do.
630.	do.	*Cocconema lanceolatum.*	Wadi Zawatin.	Do.
631.	do.	*Cocconema cymbiforme.*	Wadi Sigilliya.	Do.
632.	do.	*Gomphonema intricatum.*	Ayun Musa and Wadi.	Wilson Coll. and Ord. Surv. Coll.
633.	do.	*Gomphonema tenellum.*	Ayun Musa and Gebel Musa.	Do.
634.	do.	*Gomphonema dichotomum.*	Gebel Musa.	Ord. Surv. Coll.
635.	do.	*Meridion circulare.*	Wadi Zawatin.	Do.
636.	do.	*Achnanthes subsessilis.*	Ayun Musa and Tor.	Wilson Coll. Haig Coll.
637.	do.	*Achnanthes exilis.*	Wadi Zawatin and Gebel Musa.	Ord. Surv. Coll.
638.	do.	*Achnanthes lineare.*	Wadi Sigilliya.	Do.
639.	do.	*Fragillaria capucina.*	Ayun Musa.	Fraas and Wilson Coll.
640.	do.	*Denticula tenuis.*	Do.	Fraas Coll.
641.	do.	*Odontidium mutabile.*	Wadi Zawatin and Gebel Musa.	Ord. Surv. Coll.
642.	do.	*Tabellaria flocculosa.*	Wadi Gharba.	Do.
643.	do.	*Terpsinoe musica.*	Tor.	Haig Coll.
644.	do.	*Diatoma vulgare.*	Wadi Zawatin.	Ord. Surv. Coll.
645.	do.	*Orthosira punctata.*	Do.	Do.
646.	do.	*Orthosira arenaria.*	Ayun Musa.	Fraas and Drake Coll.
647.	do.	*Mastogloia Smithii.*	Common.	Fraas Coll. and Ord. Surv. Coll.
648.	do.	*Mastogloia lanceolata.*	Wadis Gharba and Gharandel.	Ord. Surv. Coll.
649.	do.	*Colletonema neglectum.*	Wadi Zawatin.	Do.
650.	do.	*Colletonema vulgare.*	Do.	Do.

APPENDIX III.

PREVIOUS LITERATURE.

Though treating in the main of a region immediately outside the area here specially studied, Prof. E. Hull's Memoir on the Geology and Geography of Arabia Petrœa (Palestine Exploration Fund, 1886), contains much that bears directly on the questions dealt with in this volume. With regard to the age of the igneous rocks, he considers these as being certainly more ancient than the Carboniferous, and quotes with approval Dawson's remark as to the remarkable resemblance of the rocks of the African Desert to the Laurentian series of North America, a statement which equally applies to the Sinaitic Peninsula. Two rock series are noted as present in Sinai: 1. An older metamorphic and, 2, a younger plutonic or eruptive. The former includes a grey fundamental granite or gneiss, as well as a group of hornblendic, chloritic, and talcose schists, the whole being penetrated by numerous dykes of granite, porphyry, and diorite. With special reference to Mount Serbal, he calls further attention to the central mass of eruptive granite, which has apparently burst through the flanking gneisses, an observation with which the present writer is entirely in agreement. 2. The Plutonic and Volcanic Rocks have penetrated these older members, either in the form of dykes, or in masses forming ridges and mountains, in the main these are porphyries, passing on the one hand into granites, and on the other into felstones. **Hull, 1886.**

Prof. Hull has also recognized the presence of Volcanic Fragmental Beds older than the Carboniferous Sandstone, consisting of beds of agglomerate, lapilli, and tuff, and of which he considers the red granites and porphyries as the more deeply seated representatives. An interesting account is given on pp. 37-39, a volcanic district, possibly of Lower Paleozoic or Huronian age, being postulated as existing in the Petra district. Naturally the dykes have attracted special notice, and are divided into an older felspathic, and a newer pyroxenic (hornblende and augite both included) group.

There is but little material to aid us in determining the character of the Cretaceous beds in Sinai itself, these being generally classified as Turonian and Senonian, while the Carboniferous beds have been carried far across the peninsula.

In the chapter on the Dynamical Geology not only is the importance of the Jordan-Araba fault fully recognized, but numerous minor fractures are shown to play an important part, some running parallel to the main dislocation, while others branch off from it in various directions (See figs. 17-19).

In Appendix B., Mr. F. W. Rudler has examined the specimens of rock collected by Prof. Hull, describing the syenitic gneiss from the summit of Jebel **Musa**, and a red syenitic granite from its flanks. In addition dykes of coarse red

and fine-grained pink granites, diabase and porphyrites have been noted, together with a hornblende-augite andesite from Gebel esh Shomrah.

Fraas, 1867. In "Aus dem Orient," Stuttgart, 1867, pp. 1-32, Prof. Oscar Fraas published some interesting generalizations with regard to the Sinai region. He remarks that in crossing from the sea to the mountains there are no intermediate formations between the youngest marine shore-formations and the oldest crystalline hills, and that through all time these have been absolutely wanting. At the base of Serbal he recognizes: 1. A grey very fine-grained gneiss, the constituents of which are of equal size, so that the mica has been somewhat drawn out in layers. 2. A fine red granite, mainly composed of coarsely crystalline red felspar and large colourless quartz, this forming the summit of the mountain. 3. In these are dykes of diorite-porphyry and porphyrite, and Fraas was struck by the variety of these intrusive rocks, the base-rock in Wadi Feiran being a mica-schist, then follows red granite, diorite, and finally as youngest member a porphyrite.

The oases of Sinai are always to be found in the gneiss, the water being held up by the mica-flakes, the other rocks only giving rise to bare and rocky mountain slopes, while the summit of Serbal owes its jagged character to the differential weathering of the red granite and the diorite dykes piercing it.

In the central Sinai group he recognized: 1. Grey gneiss, consisting of white quartz, some white felspar crystal and grey mica, which lies in layers in the white groundmass. This passes over through many stages to grey mica schist: 2. Dark-grey Syenite, also known as Sinait, containing colourless quartz, white felspar, and dark-green hornblende, the rock being very fine-grained and containing some titanite. 3. Dark-grey Granite, in which colourless quartz is less marked, the felspar of a redder colour, and black mica distributed in small particles. 4. Reddish granite with rose-red orthoclase, colourless quartz, and black mica. 5. Schistose Amphibolite. The hornblende is fine-grained and fibrous, penetrated by thin layers of a colourless quartz. This rock is very common in the upper portion of Wadi Hebran, and forms the pass which leads into the lower Wadi Selâf. 6. Epidote-granite forms a beautiful rock in the central portion of Wadi Hebran. Most prominent is a fine red felspar, between which is a coarse grey-white quartz, the whole mass being penetrated by light-green epidote.

Fraas also concludes that there are traces of glaciers in the whole of Sinai, and cannot agree with Russegger that the limestone fragments sometimes found in the valleys are derived from limestone only overlying the porphyries. The great débris-terraces occurring at each bend of the valleys are regarded as moraines. He also calls attention to the reversed erosion forms of the valleys, the upper portions of which are broad uplands, while lower down they form deep ravines, these fractures being ascribed to the great changes in the orographical relationships.

Walther. In "Die Korallenriffe der Sinaihalbinsel," Prof. J. Walther has mainly dealt with the nature of the coral-reefs, and as this memoir deals with West Sinai, only points of first importance need be here mentioned. He very justly points out that Fraas was mistaken as to the absence of intermediate formations between the shore and crystalline formations, and notes the extent to which faulting has

taken place. While not specially devoting his attention to the igneous or metamorphic rocks, he concludes that it is very probable that the crystalline schists and "Lagergranite" (granitoid gneiss) form the whole of the western slopes of the hills towards the Qa'a desert. The boundary of the "Stockgranite" (coarse granite, not showing gneissose structure) and "Lagergranite" correspond to a number of the most important longitudinal valleys in Sinai, and these probably owe their origin to the different relationships of the two rocks. Attention is also called to the fact that while the present strike of the hills is north-west and south-east, this having been formed after the Nummulite period, the majority of the dykes run south-west-north-east. The gneiss consists in the main of white felspar with dark mica flakes, and higher up of dark hornblende-schists.

Of great importance was his discovery of Cretaceous and Eocene beds with steep dip at the foot of the hills near Wadi Hebran, this showing clearly that these later sedimentaries had actually once covered the igneous core. Further south all the region between Qa'a plain and Wadi Hascheb consisted of granitoid gneiss dipping eastward, overlaid by porphyry tuffs and numerous eruptive rocks, amongst these being spherulitic half-vitreous masses, and a great variety of brightly-coloured dykes, from which Walther concludes that this may be an eruptive centre.

He also draws attention to the intense action of insolation on the minerals of granite and allied rocks. By day the red felspar is warmed, expanding more rapidly than the white quartz, and less than the black mica or hornblende.

Figari Bey, "Studii Scientifici sull'Egitto, etc., Lucca, 1864, pp. 625-238," made a rapid traverse from Tor along the western flank of the Sinai range to Ras Mohammed and Sherm, returning through Wadis Nasb and Dahab to Central Sinai. He further extended his researches to the greater part of the peninsula, but the scientific results are of little value, the age of the rocks having been determined by their lithological character rather than by palœontological evidence. It need only be stated that Figari recognized Jurassic strata as being widely distributed, a view which has received no support from subsequent travellers, the beds so assigned being distinctively Cretaceous. **Figari, 1864.**

E. Rüppell, "Reisen in Nubian, etc., Frankfurt, 1829, pp. 179-191, and pp. 241-274," gave one of the earliest topographical descriptions of Arabia Petrœa. He recognized that the Sinai triangle was divided into two distinct parts dependent on the formation present, the division line running from Akaba to the mouth of Wadi Feiran. South of this line are mainly ancient rocks, syenites, porphyries, and micaschists. The mountain chains run mainly from north to south. He further recognized the presence of isolated hillocks of steeply-dipping compact limestones with shell-fragments at several places on the sea-border of the ancient massif, notably north-west of Tor, near Sherm, at Ras Abu Soar and not far from Akaba. North-west of this line the principal formations are horizontally bedded compact limestone together with gypsum, forming a desolate waste. The metal-bearing veins in Wadi Nasb are also mentioned as being of wide extent, and are described in some detail (p. 265). Attention is specially called to the remarkable fissures which form a notable feature at Ras Mohammed and **Rüppell, 1829.**

in the islands to the west (Jubal, etc.), these being referred to the action of earthquakes.

Chauvet and Isambert, 1890.

In the "Itineraire de l'Orient" (Collection des Guides-Joanne), Hachette & Co., the latest edition by Chauvet and Isambert in 1890, gives full details as to Western Sinai, based on the writings of Dean Stanley, Lepsius, Robinson, Palmer and Drake, Henniker, etc. On p. 34 the statement is made that "Toute la partie sud de la peninsule est inexplorée."

APPENDIX IV.

DETAILED STRUCTURE OF IGNEOUS REGION IN EAST SINAI.

As the detailed description of the igneous rocks would practically involve the re-writing of the topography, with the addition of a statement as to the rocks composing the ranges, it is proposed to give a sequence of localities appending a note as to the rocks composing them.

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
WADI ISLA (lower part).	Biotite-gneiss, containing darker and more micaceous bands in places. Red felsite and dark dolerite dykes abundant.
WADI ISLA (east of Wadi Wajid).	Hornblende-granite.
GEBELS ETH THEMNIN and THEMAN.	Coarse red granite. Red and black dykes very common.
GEBEL HORMADJAN.	Coarse quartz-felspar granite at summit, biotite-gneiss at base near Wadi Isla.
In WADI ISLA.	No line can be drawn between the gneiss and granite, but at St. VI. the grey speckled gneissose biotite-granite is replaced by a coarse red variety (often mainly felspar).
North of UM ARAG and eastward.	Noted black dyke traversed by red granitic veins. Coarse red granite.
WADI ETH THEBT.	Bounded by coarse quartz-felspar granite.
GEBEL TELLAT GIMAL.	Fine-grained biotite-granite, much traversed by dykes.
Spur of GEBEL HUMR.	Coarse granite with dykes of porphyrite.
Junction of WADIS ETH THEBT and TARFA.	Dyke of coarse syenite in decomposed biotite granite, which here forms main mass of country.
Head of WADI TARFA.	*Red, very quartzose granite underlying* and *intruding into* the *biotite-granite.*
FERSH SHEIKH EL ARAB.	Quartzose granite with chloritized mica.
Head of WADI RAHABEH.	Biotite-Syenite, traversed by microfelsitic and syenite-felsite dykes.
WADI WA'ERA.	Biotite-granite with dykes.
WADI UM GIRAF.	Dykes carry hœmatite and hydrous oxides of iron.
GEBEL ABU MESUD.	Summit dark felsite or andesite with quartz veins on slope. Red granite apparently at base.
WADI NASB after RAHABEH.	Runs close to junction of coarse granite and biotite-gneiss. The first is a light biotite-granite the latter darker and with more hornblende. In lower portion of ravine dykes remarkably well developed.
WADI HEZA'IMA.	Coarse micaceous granite, finely graphic in places.
EKMA range, WADI NASB.	Dark felsite or andesite.
HEZAIMA to BEIDHA.	Coarse pegmatitic granite, with decomposed biotite.
GEBEL BEIDHA.	As above, with fine dolerite dykes.

* When stated without further qualification, "much traversed by dykes" means by both red felsite and dark dolerite dykes.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL NASB.	Coarse quartzose granite.
GEBEL GERAFAT.	Biotite granite.
GEBEL UM BEDA.	Drusy granite.
Hills round WADI UM GHIRAT	Mainly due to dykes of quartz and syenite-felsite, there being two dyke systems crossing one another.
WADI SENNED.	In biotite-granite, strikingly seamed by dykes.
Mouth of WADI UM RACHAL.	Purple and green schists alternating with granite.
Upper part of WADI UM RACHAL.	Hornblende-syenite, biotite-granite, and granulite penetrated by dykes of dark-green diorite.
GEBEL UM KUBBATH.	Quartz-felsite dyke in fine-grained biotite-granite.
WADI SHETHAN.	Hornblende-biotite granite, traversed by quartz-felsite and dolerite.
GEBEL THA'ALBI and ABUZAG.	Biotite-granite, traversed by quartz-felsites, etc. Quartz-veins and pockets, as well as hydrous mica, abundant.
ADAKKAR range.	Formed of acid felsites set close together.
GEBEL ASHARA and GEBEL ABU HAMAD.	Coarse pegmatite with little mica veined by dykes of dolerite.
WADI NASB (after UM RACHAL).	Biotite-granite replaced by coarse red granite.
FERANI RANGE.	Schists and felsites or andesites, with granite in places at the base.
GEBEL OWN.	Coarse granite.
Hills near WADI RAHAB.	Coarse diorite or gabbro, traversed by quartz-syenite, or spherulitic felsites.
Between SHELALA and RAHAB	Igneous conglomerate, with fragments of rhyolite.
Mouth of WADI RAHAB.	Biotite-granite, veined by many dykes.
South of KHLALAT pass.	Chlorite schists and hornfels.
GEBEL UM ZAIMER.	Biotite-granite traversed by dykes of syenite-felsites.
GEBEL ETHMOI TELLAT EL GAZAL and THAIYIB TISSIM.	Mica-schists with dolerite and micaceous granite intruding.
GEBEL ZERIG.	Micaceous-schists and knotenschiefer, traversed by dykes of diabase, quartz, and syenite-felsite. Note also re-cemented quartz pebbles. Andalusite Rock.
WADI KYD, above ETHMOI.	Passage from hornfels and chlorite-schist to mica- and finally to hornblende-schists. Finally sharp junction with coarse biotite-gneiss. In schists dykes of diorite and diorite-felsite.
GEBEL GAZALA.	Coarse granite traversed by dykes of dolerite trending N.E.-S.W.
WADI UM GERAT.	Junction of granite and schists. Granite coarse very quartzose biotite-granite. Higher up rock strikingly banded, a granitoid gneiss being interlaminated with mica- and hornblende-schists. This is succeeded by biotite granite with quartz veins, much folded and fractured, and large dykes of felsite also present.
GEBEL GERAUI.	Schists and gneisses, sometimes granitic, sometimes dioritic lithologically, traversed by thick quartz-felsite dykes.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL TAIBEKH and GEBEL SAHASIA.	Biotite-granite or gneiss, traversed by two systems of dark dioritic veins nearly at right angles to one another, and also by veins of a coarse granite.
GEBEL GENAUI.	Decomposing biotite-gneiss, traversed by veins of coarse red granite and diorite.
WADI JENDELI.	Abundance of dykes of diorite, quartz-felsite, and coarse granite. Dykes usually N.E.-S.W., others cut these at acute angles.
GEBEL MAHARRAMA.	Decomposing biotite-granite, traversed by veins of pegmatitic granite with much epidote.
WADI EL TEMA.	Junction of schists and gneiss. Composite rock produced by intimate mixture of biotite-gneiss and mica-schists. Schist with dykes of red felsites trending north-east.
GEBEL SAMRA.	Main ridge a very magnetic dolerite dyke, the schistose beds being squeezed in between the dykes of dolerite and grey granite.
Head of west end of WADI GEBILA.	Biotite-granite and schistose constituents at first, followed by hornfels, etc., with dolerite and mica syenite-felsite dykes.
GEBEL UM ZERIG.	Hornfels traversed by dykes of syenite-felsite.
GEBEL ATSHAN.	Schists obscured by abundance of gabbro and diabase dykes.
GEBEL GEBILA.	Biotite-syenite in close junction with the schists. In schists dykes N.E. trending syenite felsites and andesites.
Low hills east of above.	Coarse hornblende-biotite granite, traversed by dykes of dark green diorite.
RAS UM BERGA.	Coarse red granite traversed by diabase.
North of WADI SOMMA.	Good mica-schists followed by granite, and again a mixture of mica-schists, granulites and dolerites.
RAS EL HA'IB.	Grey compact schist traversed by purple andesite and dolerite.
WADI EL BEDA to WADI YAHAMED.	Compact grey or light hornfels with dykes containing rounded fragments of granite.
WADI YAHAMED.	Coarse pegmatite and biotite-granite, decomposing into rounded masses, with many dykes.
GEBEL ERGAIN.	Decomposing biotite-granite with dykes of diorite-felsite, coarse pegmatite, and fine-grained granite.
GEBEL UM EKHLIS.	Biotite-granite becoming distinct gneiss in places.
WADI UM METIR.	Quartzose-granite.
GEBEL UM SABBAGH.	Coarsely crystalline granite, with fine felsite dykes in lower ranges.
GEBEL UM ADOWI.	Coarse red hornblende-granite traversed by dykes of diorite.
GEBEL BARAKAT.	Coarse granite traversed by aplites and greenstone.
WADI MANDAR.	Dykes of quartz-felsite and decomposed diorite conspicuous.

Igneous rocks—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL BATTACH.	Coarse granite with dykes of quartz-felsite and diorite, or micro-granite and coarse red granite.
GEBEL THAI'AMIN.	Coarse granite traversed by diorite dykes.
GEBEL HAMRA.	Finer-grained granite than above, diorite veins on lower slopes.
GEBEL UM UWERID.	Coarse granite.
GEBEL UM TARTIR.	Biotite-granite.
GEBEL HASHUBI.	Much decomposed dykes of green felsite.
South end of Sinai.	Red granite with little mica, traversed by dykes of brown-red felsite and dolerite.
GEBEL HEDEMIA.	Red and grey quartzose granite with dykes of diorite and syenite.
WADI AWAJA region.	Maze of hills composed of 1, Biotite-Gneiss, or granite with gneissose structure, the components of which are small. 2, A medium Hornblende-Granite, grey in colour, and 3, A red granite differing only from 2 in colour.
RAS EL NIMR.	Coarse red granite with hornblende.
GEBEL DAJILAT.	Coarse, much decomposed granite.
GEBEL UM ATBAG.	Grey and red hornblende-granite with dykes of mica-diorite and dolerite.
GEBEL ER GEITA.	Biotite-granite traversed by dykes of felsite, and a number of magnetic dolerite dykes trending north-east.
GEBEL HAIMAR.	Riebeckite-granite at summit, otherwise hornblende-granite. Few dykes.
GEBEL AAD.	Base of mountain consists of porphyritic biotite-granite, almost a syenite, veined by pink granites and dolerites or diabases.
GEBEL AAD EL GHARBI.	Biotite-granite of three degrees of coarseness, the most coarse being intlimately associated with thick band of quartz-felsite and diorite.
GEBEL MNIDRI.	Red granite with little mica.
GEBEL KHANASIR and GEBEL MABLEDGE.	Coarse red granite with dykes of spheroidal diabase.
WADI UM MOBERA.	Hornblende-granite replaces coarse red variety.
GEBEL UM ZEINIG.	Hornblende-biotite-granite with porphyritic orthoclase.
GEBEL ETHNARBI.	Hornblende-granite at summit passing into coarse granite type of Sabbagh.
WADI UM ZEINIG.	Hornblende-granite with dykes of diabase. No felsites noted.
2nd JEBEL UM ZEINIG.	Coarse decomposing granite with magnetic diabase.
GEBEL EL KHOR.	Coarse decomposing biotite-granite at base passing into hornblende-biotite granite above.
GEBEL SAHARA.	Red and grey hornblende-granite traversed by diabase.
GEBEL ERGAIN.	Hornblende-granite with dykes of red granite.
Low granite region of LETIH.	Biotite or hornblende-granite with dykes of quartz felsite and spheroidal diabase.
GEBEL AJUAF.	Red granite with little mica. At summit gneiss, finer-grained with much hornblende.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL MADSUS.	Schist showing near summit, much darker and micaceous below. Felsites, dolerites, and diabases traverse them in bewildering confusion. Felsites trend north-east.
GEBEL BOTROU'IYA.	At base chlorite- and hornblende-schists, traversed by dolerite and pink felsite, summit a syenite of Amlagh type. Here distinctly gneissose.
WADI ADAKKAR.	Mainly bordered by coarsely-bedded schists, except at its head, where gneiss comes in.
Hills north of lower WADI ADAKKAR.	Grey hornblende-gneiss traversed by quartz-felsite and dolerite.
GEBEL UM ALEQ or KHALLA.	Felsite or dark andesite with syenite-felsite, etc., dykes.
GEBEL SOWILA.	Syenite with dykes of quartz-felsite, syenite-felsite and dolerite.
GEBEL UM MALAGA.	Coarse red granite with hornblende traversed by dykes of dolerite.
GEBEL NABA.	Muscovite-Granite.
St. XXVII.	Micaceous schists, in some cases containing garnets.
GEBEL ARABY.	Schists observed by gabbro and red felsite dykes.
GEBEL ABU ESHERAT.	At base gneisses and granulites with dykes of dolerite and diabase. Above a hornblende-granite.
Head of WADY ABU ESHERAT.	Red or white gneisses traversed throughout by dark diabase and red microgranite dykes.
WADI MELHADGE.	Gneiss series with dykes of coarse dolerite or gabbro replaced by massive hornblende-biotite granite itself traversed by dolerites, diabase, and non-quartzose red felsite dykes.
GEBEL UM ZAIREH.	At base dark schists, followed by shiny micaceous schists, at summit compact hornfels. Crest broken by dykes of dolerite and syenite-felsite.
GEBEL GNATHEL.	Red granite traversed by diabase dykes.
Head of WADI GNAI.	Diorite with felsites on east, red granite (muscovite-bearing) on west.
Head of WADI GNATHEL.	Finely-banded gneisses penetrated by biotite-granite.
GEBEL HAMAR EL SAJERAT.	Muscovite-granite traversed by dolerite, micro-granite, and fine-grained felsite.
Country North of G. GNAI.	Mainly granitic traversed by basic dykes.
GEBEL GNAI.	Highly quartzose granite.
Hills south of DAHAB peninsula.	Here in succession is met. 1, Highly quartzose granite followed by, 2, Hornblende-biotite syenite with sphene and, 3, Grey or red gneisses.
At back of DAHAB peninsula.	Biotite-granite with felsite and dolerite dykes.
GE EL MOQHTUT, etc.	Granite rich in quartz and porphyritic orthoclase traversed by dykes of diabase or dolerite.
GEBEL UM ET WEJERA.	Below granite capped by felsites or andesites.
GEBEL MA'IN.	Granite succeeded by fine-grained syenite intimately associated with quartz-felsites and diorite-felsites.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL LIJ.	Felsite mainly. Biotite-gneiss also present, while masses of coarse granite have burst through.
GEBEL UM HARAQ and FERANI.	Mainly dark felsites or andesites.
GEBEL ZARAGA.	Dark felsites or andesites traversed by quartz-felsites.
GEBEL ABUKSHEIB.	Biotite-gneiss at base, with felsites above.
GEBEL HAMRA.	Mainly syenite-felsites.
GEBEL SADAGIYA.	Junction of the granite and felsite series.
GEBEL JERAIMDA.	Junction of granite and felsite series. At junction hornblende-granite (with quartz) or biotite-gneiss, the hornblende granite also in fragments in pink granite.
West of WADI RA'IB.	Mica and hornblende syenite with red granite intruding.
GEBEL HAMMAM.	Rocks at base gneissose, but higher up granitic.
NASB GORGE (Eastern end).	Two different types : a non-quartzose syenite and very quartzose red granite, both traversed by dolerite.
GEBEL GURNA.	Easily decomposing biotite-granite traversed by dykes of diabase, quartz-felsite, and quartz veins.
Eastern NASB GORGE (W. end).	Hornblende and mica syenite, with red felsite and dolerite dykes.
GEBEL HEDJAN EL GIMAL.	Striped schists obscured by dykes of syenite-felsite and dolerite.
East of North trending WADI NASB.	Syenite, soon replaced by biotite-granite, the latter traversed by dykes of very quartzose granite and dolerite.
GEBEL ER RUBHA.	Coarse quartzose granite with dykes of dolerite or spheroidal diabase and felsite.
West slopes of FERANI.	Striped schists underlaid by granite, also complex intermixture of dolerite and felsite.
GEBEL EL HEYALA and West side of UM RAIYIG.	Mica-hornblende-granite traversed by dykes of felsite and diabase. Nubian sandstone on summit.
GEBEL ER RAIMSHI.	Nubian sandstone, overlying granite traversed by dykes of dolerites and syenite.
GEBEL UM RAIYIG.	Cenomanian limestones and marls overlying Nubian sandstone, between hills of Nubian sandstone overlying granite.
GEBEL ABU USHTAN, etc.	Biotite-syenite forms base rock of all district round Wadi Sa'al (Hammam).
GEBEL EL ARA'ISH.	Mica diorite, traversed by quartz-felsites.

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